Abstract: Life cycle assessment (LCA) has received attention as a tool to evaluate the environmental impacts of products and services. In the last 20 years, research on the topic has increased, and now more than 25,000 articles are related to LCA in scientific journals databases such as the Scopus database; however, the concept is relatively new in Africa, where the number of networks has been highlighted to be very low when compared to the other regions. This paper focuses on a review of life cycle assessments conducted in Africa over the last 20 years. It aims at highlighting the current research gap for African LCA. A total of 199 papers were found for the whole continent; this number is lower than that for both Japan and Germany (more than 400 articles each) and nearly equal to developing countries such as Thailand. Agriculture is the sector which received the most attention, representing 53 articles, followed by electricity and energy (60 articles for the two sectors). South Africa (43), Egypt (23), and Tunisia (19) were the countries where most of the research was conducted. Even if the number of articles related to LCA have increased in recent years, many steps still remain. For example, establishing a specific life cycle inventory (LCI) database for African countries or a targeted ideal life cycle impact assessment (LCIA) method. Several African key sectors could also be assessed further.

Keywords: life cycle assessment; LCA; Africa; review

1. Introduction

According to United Nations (UN) projections, the African population, which is composed of more than 1.2 billion people at present, is expected to double by 2050 [1]. By this time, Nigeria, South Africa, and Egypt might also enter the list of the top 30 global economies by 2050 [2]. The high population and economic growth may have an impact on environmental problems in Africa. According to an Africa Environmental Outlook (AEO3) [3] report, several environmental problems already exist in Africa, including air pollution (more than one million people die every year in Africa due to air pollution [4]), water scarcity, and toxicity due to the heavy use of chemicals.

The economies of the 54 countries of Africa are mainly based on raw products [5,6] such as oil (Angola, Algeria, and Nigeria), metals (Egypt, Ghana, and South Africa), agricultural products (cocoa beans in Cote d’Ivoire and Ghana), oilseeds (Ethiopia and Togo), or coffee (Ethiopia and Uganda).

As highlighted by Bjorn et al. (2013) [7], little has been done concerning life cycle assessment (LCA) in Africa, where networks/research groups are notably limited. LCA is a useful technique to assess the environmental impacts of a product or service throughout its entire life cycle, i.e., from the extraction of raw material through to processing, transport, use, and finally recycling/disposal [8]. By considering several different impacts over the entire life cycle, it is possible to identify potential tradeoffs from transitioning one stage
to another or from one environmental problem to another. These are major differences with other assessment methods, such as the carbon/water footprint (focusing only on one environmental aspect) or the methods focusing only on the direct emissions of products during operation. Several global life cycle inventory databases [9] and life cycle impact assessment methods [10] exist that include African information, although the impact resolutions or data are limited.

Several country reviews have been conducted in recent years, such as in Austria [11], Brazil [12], Ghana, Ivory Coast, and Nigeria [13], Indonesia [14], Portugal [15], South Africa [16], and Sweden [17]. When focusing on the reviews published for African countries, it was found that several existing studies have been omitted, and several of the reported studies were not peer-reviewed and were sometimes ordered by private sector information. Additionally, key information has not been extracted (for example, the results or type of LCI database and the data used for the assessments). The existing research gaps for African countries are similar and it would be interesting to produce a clear overview of the situation for the whole continent.

Given this situation, we decided to focus on the current published studies in Africa while focusing on life cycle assessment in order to highlight what has been done so far, but also to identify possible research gaps. This review does not apply to African LCA researchers alone, but also to anyone who has a possible interest in conducting LCA research in Africa.

2. Materials and Methods

This review was conducted with “Google Scholar” and “Scopus”, research articles published between 2000 and 2020. Keywords for this review were “life cycle assessment”, “life-cycle assessment”, “LCA”, and the name of each African country (e.g., “life cycle assessment” and “Morocco”). A total of 25,000 research articles were found when only using the keyword “life cycle assessment”, while around 400 were found for African countries. As the focus was on environmental impacts, research based on other types of life cycle assessments such as life cycle costing (LCC) or social life cycle assessment (SCLA) were excluded. Research that was not peer-reviewed was also withdrawn to preserve the neutrality of the review. As the results found in the research articles were mainly based on life cycle inventory databases based on situations in developed countries (e.g., Ecoinet v2 [9]) or European life cycle assessment methods (e.g., CML-IA [18]), similar to previous reviews, we chose to not directly compare data from one region with data from another (i.e., Asia, Europe, or America). The LCIA results that were extracted from research articles are included in the Supplementary Materials.

3. Results

3.1. Overview

A total of 199 research articles related to African LCA were found. Table A1 shows the Gross Domestic Product (GDP; Purchasing power parity (PPP), 2017 data) for each African country, as well as the main economic sector in each country and the number of published LCA studies. From Table A1 and Figure A1, it can be observed that the research published so far has not followed the economic situation in each country.

Africa’s top economies (Egypt, Nigeria, South Africa, Algeria, and Morocco) are among the most active countries concerning LCA research. On the other hand, the least developed economies (Guinea-Bissau, Central African Republic, and Djibouti) do not even have a single research article focused on LCA. Surprisingly, some advanced African economies, such as Angola or Sudan, do not have a single research article either, despite the potential interesting research topics (oil and agricultural products for example). Mauritius’s situation is singular, where, as a very active country with a relatively small GDP, Mauritius shows a good example for other African countries as the key drivers of the economy. Overall, North Africa has been the most active region, whereas many countries in Central Africa have not received any attention. South Africa is the leading country on the continent,
with more than 40 LCA studies focused on the country. South Africa has the longest history with LCA research, starting from the beginning of the 2000s. Further recommendations concerning potential research topics in the future are provided in Section 4.3.

The number of research articles published from 2010 increased when compared with 2000–2010 (Figure 1), proving that LCA received more attention; however, it can be observed that publications in recent years (2017–2020), have not followed a constant pace. Therefore, the concept is still under development for the African continent, especially when considering that the number of LCA studies conducted by African research institutes/universities is still limited (The first author was based in Africa for 121 research articles).

![Figure 1. Research articles published by year.](image)

When looking at which types of product/services have been studied the most (Figure 2), two topics received the most attention, namely, agriculture (53 articles) and energy/electricity (a total of 60 articles). This can be well understood, as many African countries rely on the agricultural sector for revenue (both from domestic consumption and overseas demand). For the electricity and energy sector, several problems exist in Africa due to solid fuel consumption in households, causing severe indoor air pollution [3]. The total electricity generation of Africa was around 800 TWh in 2020 [19] (which is nearly equal to the production of a developed country such as South Korea).

A description of each study is provided in Table 1. The main details of each research article are provided, such as the year of publication, country, product, functional unit, LCI database, and LCIA method used. In addition, Table A2 presents information such as the allocation, system boundaries, and institution of the first author for each study.

Concerning the life cycle inventory (LCI) database chosen, almost half of the research articles (100) used Ecoinvent as their LCI database, including 35 studies that used Ecoinvent v2 (mainly containing processes based on the situations in developed countries).

Concerning the Life-Cycle Impact Assessment (LCIA) method, CML was the most widely chosen (45) followed by ReCiPe (39), and EcoIndicator (24). It has to be noted that only nine studies chose ReCiPe2016 [10], one of the latest global LCIA methods, that contains characterization factors specific to African countries.
A map of the research articles published per country is provided Figure 3. Additionally, a bar graph is presented in Figure 4, with the number of articles for the top eight most studied countries. It can be observed that these eight countries account for two thirds of the total number of African LCA publications. This highlights the fact that currently only 15% of Africa has been more or less covered whereas the environmental impacts of products or services in the 85% remaining countries remain mostly undetermined. It also shows the importance of the South African LCA community compared with most of the African countries.

When looking at the institution of the first author in each article, it was found that outside Africa, France (17), Spain (10), and the UK (10) were the three countries the most linked to the African LCA research. The information for each research article is presented in Table A2.
Table 1. Summary of available life-cycle assessment (LCA) studies in Africa.

| Year  | Country [Ref.] | Product | Functional Unit | LCI Database | LCIA Method         |
|-------|----------------|---------|-----------------|--------------|---------------------|
| 2011  | Algeria [20]   | Drilling mud | 1 well drilled 4100 m deep | Primary data/Existing literature/SimaPro | IMPACT 2002+ |
| 2012  | Algeria [21]   | Recycled water | 5 L of recycled water intended to be used for irrigation | Primary data/Existing literature/Ecoinvent | Eco-Indicator 95 |
| 2013  | Algeria [22]   | Potable water | 1 L of potable water | Primary data/SimaPro | Eco-Indicator 99 |
| 2015  | Algeria [23]   | Cement | 1 ton of cement | Primary data/SimaPro 7.1 | IMPACT 2000+ |
| 2016  | Algeria [24]   | Ammonia | 1 ton of anhydrous ammonia with 99.9% purity | Primary data/GEMIS | Other |
| 2017  | Algeria [26]   | Mussels | 1 ton of fresh Mediterranean mussels | Primary data/Existing literature/Ecoinvent v3 | CML |
| 2017  | Algeria [27]   | Hotel building | impact/occupant/m² | Primary data/Ecoinvent | Other |
| 2017  | Algeria [28]   | Biodiesel | 1 ton of biodiesel | Primary data/Existing literature/Ecoinvent v3.1 | IMPACT 2002+ |
| 2020  | Algeria [29]   | PV Energy | 1 year of utilization | Primary data | Other |
| 2014  | Benin [30]     | Tomatoes | 1 hectare | Primary data | ILCD |
| 2017  | Benin [31]     | Tomatoes | 1 kg of product | Primary data/Existing literature/Ecoinvent v2.2 | ReCiPe2008 |
| 2016  | Burkina Faso [32] | Energy sources for a water purification plant | One year | Ecoinvent v3 | ReCiPe |
| 2018  | Burkina Faso [33] | Jatropha biofuel | hectare/year/gigajoule of J. curcas SVO or JME | Primary data/Existing literature | ReCiPe |
| 2018  | Burkina Faso [34] | PV | 1 L of oil | Ecoinvent | ReCiPe World E/A |
| 2010  | Cameroon [35]  | Palm Oil | 1 MJ in a car engine | Primary data/Existing literature/LCA database | Other |
| 2010  | Cameroon [36]  | Road | Number of vehicles moving on that road for a period of fifty years | Primary data/Existing literature | Other |
| Year | Country [Ref.] | Product | Functional Unit | LCI Database | LCIA Method |
|------|----------------|---------|----------------|--------------|-------------|
| 2012 | Cameroon [37]  | Farms   | 1 ton of fresh fish (both tilapia and African catfish) at the farm exit gate | Existing literature/Ecoinvent | CML2001 |
| 2016 | Cameroon [38]  | Waste Water | 1 life-cycle | Primary data/Existing literature | Other |
| 2019 | Cameroon [39]  | Jatropha | 1 MJ of JVO obtained | Primary data/Existing literature/Ecoinvent v2 | Other |
| 2010 | Egypt [40]     | Wastewater | Treatment of 1 m³ of wastewater | Primary data/Existing literature | Eco-Indicator 99 |
| 2012 | Egypt [41]     | Wastewater | Treatment of 1 m³ of wastewater | Existing literature | Eco-Indicator 99 |
| 2014 | Egypt [42]     | Building materials (Method) | - | - | - |
| 2014 | Egypt [43]     | Residential building | 1 usable floor space (m²) | Primary data/Existing literature/Ecoinvent v3 | IMPACT 2002+ |
| 2014 | Egypt [44]     | Building database | - | - | - |
| 2014 | Egypt [45]     | Cotton | 1 kg of dyed cotton yarn | Primary data/Ecoinvent v2 | Eco-Indicator 99 |
| 2015 | Egypt [46]     | Diesel fuel, solar pump | Irrigation of 1 feddan of rice | Primary data | IMPACT 2002+ |
| 2015 | Egypt [47]     | Jatropha Biodiesel | 1 ton of Jatropha Biodiesel | Primary data | IMPACT 2002+ |
| 2016 | Egypt [48]     | Dredged Material | 1 trip per day | Primary data/SimaPro 8 | IMPACT 2002+ |
| 2016 | Egypt [49]     | Energy system | The operation of the power supply system for a calendar year | Existing literature/ecoinvent | Eco-Indicator 99 |
| 2016 | Egypt [50]     | Aquaculture | 1 ton of live tilapia at the farm gate | Primary data/Existing literature/Ecoinvent v2.2 | Other |
| 2016 | Egypt [51]     | LCA tool | - | - | - |
| 2016 | Egypt [52]     | Transport vehicles | Total Vehicle Kilometers Traveled (VKT) in Egypt | Primary data?/Existing literature | IMPACT 2002+ |
| 2016 | Egypt [53]     | Tilapia | 1 ton of Tilapia | Primary data/Existing literature/Ecoinvent v2 | CML baseline 2000 |
| 2016 | Egypt [54]     | Acrylic fiber | 1 kg production of acrylic fiber. | Primary data/Existing literature/Ecoinvent v2.2 | Eco-Indicator 99 |
Table 1. Cont.

| Year | Country [Ref.]     | Product                  | Functional Unit                                      | LCI Database                          | LCIA Method    |
|------|--------------------|--------------------------|------------------------------------------------------|---------------------------------------|----------------|
| 2016 | Egypt [55]         | Cement                   | 1 kg of cement                                       | Primary data/Ecoinvent v3             | IMPACT 2002+   |
| 2016 | Egypt [56]         | Acrylic fiber            | 1000 kg production of acrylic fiber.                 | Primary data/Ecoinvent v2             | Eco-Indicator 99|
| 2017 | Egypt [57]         | Bricks                   | 1 kg of brick products                               | Primary data/Existing literature/IDEA | LIME2          |
| 2017 | Egypt [58]         | Lubrication oil          | 1000 kg lubrication used oil                         | Existing literature/Ecoinvent v2     | Eco-Indicator 99|
| 2017 | Egypt [59]         | Waste water              | 1 m³ of treated wastewater                          | Primary data/Existing literature/Ecoinvent v2 | CML2000      |
| 2019 | Egypt [60]         | Waste                    | 1 ton of waste                                       | Primary data                          | Other          |
| 2019 | Egypt [61]         | Wastewater               | 1 m³ of treated wastewater                          | Primary data/Gabi                    | ReCiPe         |
| 2019 | Egypt [62]         | Bioethanol               | 1 ton of bioethanol                                  | Primary data/Existing literature/Ecoinvent v3 | CML-IA        |
| 2012 | Ethiopia [63]      | Rose cultivation         | 1 bunch of roses consisting of 20 stems             | Ecoinvent v2                         | CML 2 baseline 2000 |
| 2017 | Ethiopia [64]      | Biogas, dung             | Amount of primary energy needed to provide energy carriers | Primary data/Existing literature/ecoinvent v2.2 | CML2001       |
| 2017 | Ethiopia [65]      | Milk                     | 1 adult cattle unit (cu)/1 kg of milk produced by a cow | Primary data/Existing literature/Ecoinvent v2.2 | Other         |
| 2020 | Ethiopia [66]      | Electricity from a wind farm | The generation of 1 kWh of average electricity   | Primary data/Existing literature/Ecoinvent v3 | ReCiPe 2008  |
| 2012 | Ghana [67]         | Cooking fuels            | 1 MJ of energy delivered to the cooking pot         | Primary data/Ecoinvent/Gabi 4        | CML2001       |
| 2020 | Ghana [68]         | Building                 | 180.50 m² gross floor area (GFA) for a lifespan of 50 years | Primary data/ICE                      | Other         |
| 2020 | Ghana [69]         | Food products            | 1 kg of product/1 kcal unit                          | Existing literature/Ecoinvent v3.5   | CML2001/ReCiPe2008 |
| 2011 | Ghana [70]         | Timber                   | 1 kg/1 euro/1 m³ of product produced                | Existing literature                  | CML2000       |
| 2011 | Ghana [71]         | Biogas                   | Production of 1 MJ of useful energy                 | Primary data/Ecoinvent/Gabi 4        | CML2001       |
| 2011 | Ghana [72]         | Cyanide containers        | 1 package                                            | Primary data/Existing literature      | Eco-Indicator 99|
| Year | Country [Ref.] | Product | Functional Unit | LCI Database | LCIA Method |
|------|----------------|---------|-----------------|--------------|-------------|
| 2010 | Ghana [73]     | Timber  | 1 m³/1 kg/1 euro| Primary data | Other       |
| 2008 | Ghana [74]     | Cocoa   | 1 kg of cocoa beans processed | Primary data/Ecoinvent/Gabi 4 | CML2001     |
| 2009 | Ivory Coast [75]| Biofuel | 1 MJ of JME     | Primary data/Ecoinvent | Other       |
| 2007 | Kenya [76]     | Food products | 1 ton of grade 1 product | Existing literature/Ecoinvent | CML baseline 2000 |
| 2016 | Kenya [77]     | Biowaste | 1 kg of wet biowaste | Primary data/Existing literature/Ecoinvent v3.3 | ReCiPe 2016 |
| 2017 | Kenya [78]     | Solar photovoltaic microgrid system | 1 kWh of electricity consumed by the community | Ecoinvent v2.2/Gabi 6 | ReCiPe 2008 |
| 2017 | Kenya [79]     | Solar photovoltaic microgrid system | 1 kWh of electricity consumed by the community | Ecoinvent v2.2/Gabi 6 | ReCiPe 2008 |
| 2020 | Kenya [79]     | Solar photovoltaic microgrid system | 1 kWh of electricity consumed by the community | Ecoinvent v2.2/Gabi 6 | ReCiPe 2008 |
| 2020 | Kenya [80]     | Solar photovoltaic microgrid system | 1 kWh of electricity consumed by the community | Ecoinvent v2.2/Gabi 6 | ReCiPe 2008 |
| 2020 | Kenya [80]     | Solar photovoltaic microgrid system | 1 kWh of electricity consumed by the community | Ecoinvent v2.2/Gabi 6 | ReCiPe 2008 |
| 2020 | Kenya [80]     | Solar photovoltaic microgrid system | 1 kWh of electricity consumed by the community | Ecoinvent v2.2/Gabi 6 | ReCiPe 2008 |
| 2020 | Kenya [80]     | Solar photovoltaic microgrid system | 1 kWh of electricity consumed by the community | Ecoinvent v2.2/Gabi 6 | ReCiPe 2008 |
| Year | Country [Ref.] | Product | Functional Unit | LCI Database | LCIA Method |
|------|----------------|---------|----------------|--------------|-------------|
| 2012 | Mauritania [93] | Octopus | 24 kg carton of frozen common octopus up to the point of import in the year 2009. | Primary data/Ecoinvent/LCA Food Database | CML baseline 2000 |
| 2014 | Mauritania [94] | Building materials | Structure and envelope of a classroom block consisting of eight modules in Nouakchott for a period of 30 years | Ecoinvent v2.2 | Other |
| 2004 | Mauritius [95] | Sugarcane | 1 ton of raw cane sugar exported | Primary data/Existing literature | CML |
| 2005 | Mauritius [96] | Biodegradable waste | Treatment of 1 kg of biodegradable wastes by composting and Anaerobic Digestion (AD) | Primary data | Other |
| 2008 | Mauritius [97] | Electricity generation bagasse | 1 GWh of electricity exported to the national electricity grid | Primary data/Existing literature/BUWAL 2000 | Eco-Indicator 99/CML World 92 |
| 2008 | Mauritius [98] | polyethylene terephthalate (PET) bottle | Use and disposal of 1000 packs of 1.5 LPET bottles, used for the packaging of 9000 liters of beverage | Primary data/BUWAL 2000 | Eco-Indicator 99 |
| 2011 | Mauritius [99] | Waste | The disposal of 300,000 tons of Municipal Solid Waste (MSW) in one year | Primary data | IMPACT 2002+ |
| 2012 | Mauritius [100] | PET bottle | 1 ton of used PET bottles supplied to the respective disposal facilities | Primary data | Eco-Indicator 99 |
| 2012 | Mauritius [101] | PET bottle | 1 ton of used PET bottles | Primary data/Existing literature/SimaPro 7.1 | Eco-Indicator 99 |
| 2012 | Mauritius [102] | PET bottle | 1 ton of used PET bottles | Primary data/Existing literature/Ecoinvent | Eco-Indicator 99 |
| 2015 | Mauritius [103] | Electricity generation | 1 MWh of electricity delivered to the consumer | Primary data/Ecoinvent v2 | CML 2 Baseline 2001 |
| 2017 | Mauritius [104] | Waste | The management of 427,687 t of MSW generated in the year 2010 | Existing literature/Ecoinvent v2.0 | CML-IA |
| 2014 | Morocco [105] | Tomatoes | 1 kg of fresh bulk tomatoes delivered at the Saint-Charles International Market entry gateway | Primary data/Ecoinvent v2.2 | ReCiPe |
| Year  | Country [Ref.] | Product                        | Functional Unit                                      | LCI Database              | LCIA Method      |
|-------|----------------|--------------------------------|-----------------------------------------------------|---------------------------|------------------|
| 2014  | Morocco [106]  | Perennial crops                | 1 kg of fresh fruits                                 | Primary data/Ecoinvent v2.2 | ReCiPe 2008      |
| 2016  | Morocco [107]  | Clementines                    | 1 kg raw fruit at the farm gate                      | Ecoinvent v2.2             | ReCiPe           |
| 2016  | Morocco [108]  | Photovoltaic power plant       | 1 MWh                                               | Ecoinvent v3               | ReCiPe           |
| 2016  | Morocco [109]  | Photovoltaic power plant       | 1 MW                                                | Ecoinvent v2.2             | Other            |
| 2016  | Morocco [110]  | Fresh fruit                    | 1 kg of fresh fruits                                 | Primary data/Ecoinvent v2.2 | ReCiPe 2008      |
| 2018  | Morocco [111]  | Electric energy                | 1 kWh of produced electric energy                   | Primary data/Gabi/Ecoinvent v3.1 | CML2001          |
| 2019  | Morocco [112]  | Automotive headrest            | 1 headrest for automotive seating                   | Primary data/Ecoinvent     | IMPACT 2002+     |
| 2020  | Morocco [113]  | Hybrid solar/biomass micro-cogeneration | 1 kWh of electricity                      | Primary data/WIOD/EORA ILCD | Other            |
| 2020  | Morocco [114]  | Solar water heater             | Utilization during one year                         | Primary data               | Other            |
| 2020  | Morocco [115]  | Waste Water                    | Treat effluent of one population equivalent for one day | Primary data               | ReCiPe midpoint 2014 |
| 2013  | Mozambique [116] | Jatropha oil                  | 1 MJ of energy in the form of jatropha oil or fossil diesel | Primary data/Existing literature | Other            |
| 2016  | Mozambique [117] | Biomass power plant          | 1-GJ pellets delivered to a combined heat and power (CHP) plant | Primary data/Existing literature | Other            |
| 2010  | Nigeria [118]  | Future electricity scenarios   | 56,160 TJ/yr for 2003; 346,000 TJ/yr for 2010; 551,000 TJ/yr for 2020; 764,000 TJ/yr for 2030 | Primary data/Existing literature/GEMIS 4.3/SimaPro | Other            |
| 2014  | Nigeria [119]  | Biodigesters                   | One meal                                            | x                          | Other            |
| 2015  | Nigeria [120]  | Residential building           | One life-cycle                                      | Primary data               | Other            |
| 2015  | Nigeria [121]  | Municipal solid waste management | Waste Management scenarios                         | Primary data/Ecoinvent     | Other            |
| 2015  | Nigeria [122]  | Jatropha biofuel               | 1 MJ of fuel used in a typical biodiesel-fired power plant/Jatropha plantation of 1 hectare (ha) over a 20-year period | Literature review/Agrifootprint/Ecoinvent | Other            |
| 2016  | Nigeria [123]  | Shea butter                    | 1 kg of shea butter                                 | Primary data/Ecoinvent     | TRACI            |
Table 1. Cont.

| Year | Country [Ref.] | Product | Functional Unit | LCI Database | LCIA Method |
|------|----------------|---------|-----------------|--------------|-------------|
| 2019 | Nigeria [124]  | Electricity | 1 kWh of electricity generation | Existing literature/Gabi | CML 2001 |
| 2020 | Nigeria [125]  | Electricity | 1 MWh of net electricity produced | Primary data/Ecoinvent | CML 2001 |
| 2020 | Nigeria [126]  | Cowpeas | 1 ton of grain | Primary data/Gabi 8.7 | CML |
| 2020 | Nigeria [127]  | Cassava | 1 ha land area | Primary data/Existing literature | Other |
| 2020 | Nigeria [128]  | Sweet Oranges | 1 ha | Primary data | Other |
| 2013 | Nigeria [129]  | Passenger transport | 467 billion people/km in 2003/721 billion people/km in 2020/942 billion people/km in 2030 | Existing literature/GEMIS4.3 | CML 2001 |
| 2013 | Nigeria [130]  | Biodiesel | The functional unit was defined as one kilogram of soybean | Primary data/Existing literature | Other |
| 2017 | Nigeria, Ghana, ivory coast [13] | Review | - | - | - |
| 2019 | Rwanda [131] | Tomatoes | 1 kg of tomatoes at farm-gate | Existing literature/Ecoinvent v2.2 | ILCD |
| 2011 | Senegal [132] | Shrimp products | 1 kg of shrimp and the accompanying packaging material at the point of import to Europe | Primary data/Existing literature/Ecoinvent v2 | CML 2002 |
| 2019 | Somalia [133] | Treated water | 1 L of treated water | Existing literature/Ecoinvent v3.4 | ReCiPe 2008 |
| 2002 | South Africa [134] | Review | - | - | Review |
| 2002 | South Africa [135] | Wool | 1 kg of dyed two-fold wool yarn | Primary data/Existing literature | Method |
| 2002 | South Africa [136] | Potable water | 1 kL of potable water | Primary data/Gabi 3 | ReCiPe |
| 2003 | South Africa [137] | Method | - | - | - |
| 2006 | South Africa [138] | Water supply | 1 Mt/d of potable water supplied at Rosslyn | Primary data | special African |
| 2009 | South Africa [139] | Urban water | 1 kL of water | Primary data/Existing literature/Gabi 3 | CML |
| 2010 | South Africa [140] | Sugar | 1 ton of raw sugar | Primary data/Ecoinvent | Eco-Indicator 99 |
| 2012 | South Africa [141] | Photovoltaic/Wind Radio | One radio base station utilization during 10 years | Primary data | ReCiPe2008 |
| 2014 | South Africa [142] | Container glass waste | 1 ton of container glass waste | Primary data/Ecoinvent v2 | Other |
| Year | Country [Ref.] | Product | Functional Unit | LCI Database | LCIA Method |
|------|----------------|---------|----------------|--------------|-------------|
| 2014 | South Africa [143] | Clay brick Walling | 1 standard brick equivalent (SBE) | Primary data/Ecoinvent v2.2 | IMPACT 2002+ |
| 2014 | South Africa [144] | Polymer bag | 1 m² of plastic film | Primary data/Ecoinvent v2.2 | IMPACT 2002+ |
| 2015 | South Africa [145] | Biofuel | 1 km traveled | Aspen simulation/Existing literature/Ecoinvent v2.2/GREET 2.7 | Other |
| 2016 | South Africa [146] | Agriculture | 1 metric ton of extractable sucrose delivered at the mill gate in the form of sugarcane stems or billets. | Primary data/Existing literature/Ecoinvent v2.2/GREET | Other |
| 2016 | South Africa [147] | Method for constructing LCAs | - | - | - |
| 2016 | South Africa [148] | Books | The reading of 21 books by a single user in two hours per day over a four-year period | Ecoinvent v3 | ReCiPe 2008 |
| 2016 | South Africa [149] | Lignocellulosic lactic acid | 1 ton of Lactic Acid (LA) produced | Aspen/Ecoinvent | ReCiPe |
| 2017 | South Africa [150] | Timber | Quantity of materials required to construct the roof truss system of a house | AUSLCI/Ecoinvent v3.1 | ReCiPe |
| 2017 | South Africa [151] | Maize | one kilogram of maize in silo storage | Primary data/Existing literature/Ecoinvent v3.3 | ILCD |
| 2017 | South Africa [152] | Meat | 1 kg of LW meat/1kg of CW meat | Primary data/Ecoinvent | CML IA |
| 2017 | South Africa [153] | Biorefineries | a biorefinery with a processing capacity of 65 (IDM/h) tons bagasse and trash per hour | Primary data/Existing literature | Eco-Indicator 99 |
| 2017 | South Africa [154] | Biorefineries | 1 MWh electricity produced | Aspen simulation/Existing literature/Ecoinvent v3 | CML-IA baseline 3.02 |
| 2017 | South Africa [155] | Biorefineries | 1 MWh electricity produced | Aspen simulation/Existing literature/Ecoinvent | CML-IA baseline 3.02 |
| 2017 | South Africa [156] | Biorefineries | 1 ton BD produced/1 MWh electricity produced | Aspen simulation/Existing literature/Ecoinvent v3 | CML-IA baseline 3.02 |
| 2017 | South Africa [157] | Zinc oxide | ZnO surface area (1 m²/g) | Primary data/Existing literature | ReCiPe |
| 2017 | South Africa [158] | Domestic Biogas Digester | 1 MJ | Primary data | Other |
Table 1. Cont.

| Year | Country [Ref.] | Product                        | Functional Unit                                                                 | LCI Database                       | LCIA Method          |
|------|----------------|--------------------------------|--------------------------------------------------------------------------------|------------------------------------|---------------------|
| 2018 | South Africa   | Sandstone                      | 1 t of sandstone                                                               | Primary data/Existing literature   | IMPACT 2002+        |
| 2018 | South Africa   | Acid mine drainage (AMD)       | 1 m³ of effluent generated by an AMD reactor                                  | Primary data/Existing literature   | ReCiPe2016          |
| 2018 | South Africa   | Sanitation system              | The provision of a sanitation service for the daily defecation of a 10-adult    | Primary data/Ecoinvent v3.0        | ReCiPe2016          |
| 2018 | South Africa   | Soybean Biodiesel              | 1 L of Biodiesel                                                               | Existing literature                | Other               |
| 2018 | South Africa   | Sugarcane Ethanol (Inventory)  | -                                                                               | -                                  | -                   |
| 2019 | South Africa   | Seawater desalination          | 1 kL of potable water                                                          | Primary data/Existing literature   | ReCiPe              |
| 2019 | South Africa   | Method for the Construction industry | -                                                                                 | -                                  | -                   |
| 2019 | South Africa   | Coal power plant               | 712-MW power-generating unit                                                   | Primary data/Ecoinvent             | Eco-Indicator 99    |
| 2020 | South Africa   | Straw                          | Annual straw consumption per capita                                            | Primary data/Ecoinvent v3.5        | ReCiPe              |
| 2020 | South Africa   | Review                         | -                                                                               | -                                  | -                   |
| 2020 | South Africa   | Wastewater                     | 1 L of real wastewater                                                         | Primary data/Ecoinvent v3.6        | ReCiPe2016          |
| 2015 | South Africa   | Sugarcane                      | 1 ton of extractable sucrose produced leaving the farm gate                     | Primary data                       | Other               |
| 2012 | South Africa   | Pork                           | 1 kg of pork (carcass weight)                                                  | Existing literature/Gabi 2006      | CML2001             |
| 2012 | South Africa   | Saline wastewater              | A daily production of 40 ton of dehydrated sodium sulphate by each process and  | Existing literature/Ecoinvent v2.2 | IMPACT 2002+        |
| 2012 | South Africa   | Water treatment                | 1000 m³ of boiler feed water (BFW)                                             | Existing literature/Ecoinvent      | CML 2 baseline 2000 V2.04 |
| 2010 | South Africa   | Biodiesel                      | 1 ton of biodiesel                                                             | Primary data/Existing literature   | Other               |
| 2010 | South Africa   | Biofuel                         | A unit of product, over a one-year production period                           | Primary data/Existing literature   | -                   |
| Year  | Country [Ref.] | Product                                      | Functional Unit                                                | LCI Database            | LCIA Method          |
|-------|----------------|----------------------------------------------|----------------------------------------------------------------|-------------------------|----------------------|
| 2002  | South Africa [175] | Water recycling plant                        | 1 kL of water as supplied to industry                         | Primary data/Gabi3      | CML                  |
| 2007  | Tanzania [176]  | Production of biofuels from pyrolysis of wood | One year                                                       | Primary data            | Other                |
| 2012  | Tanzania [177]  | Electricity                                  | The functional unit for this study is 1 MW h net electricity at the power plant. | Ecoinvent v2.2/USLCI 1.6.0 | CML(IA)              |
| 2013  | Tanzania [178]  | Bioethanol produced from sugarcane molasses  | 1 ton of combusted jatropha biodiesel.                         | Primary data/Existing literature/Ecoinvent | CML (IA)            |
| 2014  | Tanzania [179]  | Electricity                                  | 1 MWh gross electricity generated at the power plant.         | Ecoinvent v2.2/USLCI 1.6.0 | CML (IA)            |
| 2014  | Tanzania [180]  | Maize                                        | One ton of Maize                                               | Primary data/Existing literature/Gabi 4 | Other                |
| 2016  | Tanzania [181]  | Review                                       | -                                                              | -                       | -                    |
| 2020  | Tunisia [182]   | PV Electricity                               | 1 m² of PV module                                              | Primary data            | Other                |
| 2007  | Tunisia [183]   | Coastal area                                 | 1 L of water sample                                            | Primary data            | Other                |
| 2011  | Tunisia [184]   | Sea bass                                     | 1 ton of live fish weight produced.                           | Primary data/ecoinvent  | CML 2 Baseline 2000  |
| 2012  | Tunisia [185]   | Jatropha biodiesel                           | 1 hectare of Jatropha                                          | Primary data/Existing literature | Other                |
| 2013  | Tunisia [186]   | Olive-waste cake                             | 1 kg of AC from by-product olive-waste cakes                   | Primary data/Existing literature/Ecoinvent v2.2 | CML 2 Baseline 2000  |
| 2014  | Tunisia [187]   | Groundwater pumping system                   | 1 m³ pumped at a 35 m depth, 2 bars of pressure, and 0.9 bars of friction losses in pipes | Ecoinvent v2.2         | ReCiPe               |
| 2015  | Tunisia [188]   | Shale gas                                    | 1 MJ of shale gas                                              | Primary data            | ReCiPe v1.06         |
| 2017  | Tunisia [189]   | Sheep/chicken meat                           | 1 kg of carcass                                                | Primary data/Existing literature | Other                |
| 2017  | Tunisia [190]   | Sea cages                                    | 1 ton of live fish                                             | Primary data/Ecoinvent v3 | Other                |
| 2017  | Tunisia [191]   | Seabass                                      | 1 ton of fish at the fish farm gate                           | Primary data/Ecoinvent v3 | CML2 baseline 2000   |
| 2017  | Tunisia [192]   | Sulfuric acid production system              | 1 ton of sulfuric acid                                         | Primary data/Ecoinvent v3 | ILCD                 |
| 2017  | Tunisia [193]   | tomatoes                                     | 1 ton of soilless geothermal greenhouse cherry tomatoes        | Primary data/Ecoinvent v3.3 | ILCD                 |
| Year | Country [Ref.] | Product | Functional Unit | LCI Database | LCIA Method |
|------|----------------|---------|-----------------|--------------|-------------|
| 2018 | Tunisia [194]  | fisheries (seafood) | 1 ton of landed seafood by demersal trawlers in the Gulf of Gabes | Primary data/Ecoinvent v3 | CML baseline 2000 |
| 2019 | Tunisia [195]  | Agricultural practices | 1 ha/1 dinar | Primary data/Existing literature/Ecoinvent | ReCiPe2016 |
| 2020 | Tunisia [196]  | Ground water irrigation | Area of land cropped over 1 year | Primary data/Existing literature | ReCiPe 1.07 |
| 2020 | Tunisia [197]  | Tomatoes | 1 ton of soilless cherry tomato produced. | Primary data/Ecoinvent v3.3/Agrifootprint 3.0 | ILCD |
| 2020 | Tunisia [198]  | Electricity | 1 MWh of electricity generated | Primary data/WIOD/SimaPro | ILCD |
| 2020 | Tunisia [199]  | Electricity | 1 kWh of electricity output | Primary data/Existing literature | ILCD |
| 2020 | Tunisia [200]  | Olives | 1 ton of olives and 1 ha of cultivated olive growing area | Primary data/Ecoinvent v3.2 | ILCD |
| 2020 | Tunisia [201]  | Seafood | 1 t of landed seafood | Primary data/Ecoinvent v3 | ILCD |
| 2013 | Uganda [202]   | Sanitary products | Number of sanitary pads needed to provide effective protection from menstruation for one woman over one year. | Ecoinvent v2.2 | IMPACT 2002+ |
| 2014 | Uganda [203]   | Waste | The waste production for the base year 2011 | Primary data/Existing literature | Other |
| 2014 | Uganda [204]   | Charcoal | 1 kg of charcoal produced and utilized | Primary data/Existing literature | CML2001 |
| 2016 | Uganda [205]   | Water | 3.57 L of potable water | Primary data/Existing literature/SimaPro | Eco-Indicator 99 |
| 2016 | Uganda [206]   | Waste | 1 ton of impurity-free anima waste treated to produce a quality soil improver/fertilizer. | Primary data/Existing literature | CML |
| 2019 | Uganda [207]   | Juice, dry fruits | 1 L of packaged juice ready for consumption/1 kg of packaged dried fruits including the non-edible parts | Primary data/Existing literature | CML2001 |
| 2012 | Zambia [208]   | Biochar | 1 ton of maize | Primary data/Existing literature/Ecoinvent v2.2 | ReCiPe (a voir) |
| 2017 | Zambia [209]   | Biochar production System | Preparation and sequestration of 1 kg biochar | Primary data/Existing literature/Ecoinvent v3.2 | ReCiPe |
Table 1. Cont.

| Year | Country [Ref.] | Product                          | Functional Unit                        | LCI Database                        | LCIA Method          |
|------|----------------|----------------------------------|----------------------------------------|-------------------------------------|----------------------|
| 2007 | Zimbabwe [210] | Plastic carrier bags             | 1 kg of polyethylene                   | Primary data/Existing literature/Gabi 3 | Other                |
| 2007 | Zimbabwe [211] | Paper                            | 53 gsm (g/m²) newsprint paper produced in Zimbabwe from the pulping of pinewood | Primary data | Eco-Indicator 99 |
| 2008 | Zimbabwe [212] | Vehicle leaf springs             | One life-cycle                         | Primary data                        | Eco-Indicator 99    |
| 2008 | Zimbabwe [213] | Cement                           | 1 ton of cement                        | Primary data                        | Eco-Indicator 99    |
| 2015 | Zimbabwe [214] | Steel balls                       | 1 kg of steel                          | Primary data                        | Other                |
| 2019 | Zimbabwe [215] | Municipal solid waste management | Annual generation of MSW              | Ecoinvent v3                        | ReCiPe 2016         |
| 2020 | Zimbabwe [216] | Waste                            | Annual biodegradable waste generation for Harare and its dormitory towns | Existing literature/Ecoinvent v3    | ReCiPe 2016 v1.02   |
3.2. A Focus on LCA for Agricultural Products

Several points can be highlighted regarding the research on agricultural products. For fisheries, Lourguioui et al. [26] found in Algeria that a reduction of 3150 MJ and 156 kg CO$_2$eq per ton of fresh mussels could be reached if mussel farming activities would be operated in cooperation, instead of the traditional competitive scheme, as the resulting efficiency would be higher. The authors also highlighted the importance of applying LCA...
to the seafood production sector in Algeria. In Egypt [50], the importance of management practices was also highlighted to produce Nile Tilapia, carps, and mullets. By choosing better practices, life cycle impacts could be reduced by 22%. In Tunisia [184,191], it was shown that the production of seabass was an important source of nitrogen and phosphorus releases due to the fish feed. Cascade raceways featured higher impacts than traditional raceways. In sub-Saharan Africa, fish also constitute one of the main sources of animal protein. In Cameroon [37], the eutrophication impact was higher for Cameroon farms than for an intensive trout monoculture (France) or extensive carp polyculture (Brazil) due to poor water and poor manure management. In Senegal [132], F. Ziegler et al. found that artisanal fisheries have far lower inputs and emissions in the fishing phase compared with industrial fisheries. The global warming impacts from artisanal fisheries mainly come from the use of heavy fuel oil and low-quality refrigerants.

For the beef and dairy industries, D. Woldegebriela et al. [65] found out that milk production in Ethiopia had a higher global warming impact (1.75–2.22 kg CO$_2$eq/kg milk) than other developing countries due to the large amounts of low-quality feeds fed.

For fruit and vegetable products, C. Basset-Mens et al. [107] showed that compared with mangoes from Brazil or peaches/apples from France, it could be observed that except for terrestrial acidification and marine eutrophication, the results were higher for all the other impact categories for clementine production in Morocco. There are several reasons that explain these results: the higher amount of fertilizer used (6 kgN/kg) and the high amount of water needed to grow clementines (8000 m$^3$/hectare compared with 2.767 for apples grown in France), despite the fact that water is scarce in Morocco and it has to be withdrawn from more than 100 meter deep wells. The energy required to pump this water is also important (22,830 MJ per hectare compared with 2946 for mangoes grown in Brazil). Moreover, the Moroccan electricity mix is composed of more than 50% fossil energy (coal), which explains why the impact of climate change was also high. S. Peyen et al. [105] also showed that tomato cultivation had a higher impact in Morocco than in France (28 vs. 7.5 L H$_2$Oeq/kg). They highlighted the importance of LCA for other impact categories (e.g., total energy consumption and global warming), which showed higher results in the case of France.

For forestry, in Ghana [73], it was found that the wastage of wood during timber processing contributed considerably to resource depletion, and land use impact was also a major concern, while kiln-dried lumber, plywood, and veneer production lines affected CO$_2$ emissions considerably. Relatively high energy consumption was also reported due to biomass combustion for drying wood products.

For other types of crops such as cocoa [69], it was revealed that even though fertilizer and pesticide usage was low, the water consumption was higher in Ghana’s plantations than in other parts of the world such as Ecuador or Indonesia. For cassava, a major crop cultivated mainly in Western Africa, it was calculated that the higher energy consumption came from planting operations, where the global warming potential (GWP) per one hectare was about 80 kg CO$_2$eq.

### 3.3. A Focus on LCA for Energy

The second topic that has received interest is life cycle assessment for energy and electricity systems.

Jatropha is often one of the preferred choices in Africa to replace conventional transport fuel. In Burkina Faso [33], it was found that its production could reduce both GHG emissions and energy consumption by around 80% when compared with diesel fuel. One of the main challenges is the land transformation that implies the quantity of energy output per hectare was limited (less than 10 GJ/ha). Therefore it could become a competitor of food crops. Another type of biodiesel is made using palm oil [35], where the results for Cameroon confirmed this tendency with a reduction of 70% compared with conventional fuel in the range of 60–80 g CO$_2$/MJ. Proton-exchange membrane fuel cells have also received attention; however, the results found in Morocco [111] were much higher than
those in Norway (4040 g CO\(_2\) vs. 239 g/kWh) due to the electricity generation primarily based on fossil fuels for hydrogen production.

For cooking fuel, biogas is also an option to reduce the impacts of indoor air pollution. J. Lanche et al. [64] showed that 130,542 t CO\(_2\)eq could be saved annually in Ethiopia if dung cakes were replaced with biogas. Indoor air pollution could also be avoided as dung combustion contributes to significant Nitrogen Oxide (NOx) and Particulate Matter (PM) emissions.

The use of renewables for electricity has been studied extensively. Several researchers have pointed out the need to develop photovoltaic (PV) systems and biomass power plants. R. Brizmohun et al. [103] pointed out the impacts of African fossil fuel power plant plants by analyzing the emissions of Mauritian plants. The global warming potential of electricity from coal was estimated to be 1444 kg CO\(_2\)eq/MWh, which is about six times the minimum value obtained in the literature. The lack of abatement technology for PM2.5, SO\(_2\), and NO\(_x\) was highlighted, as well as the higher sulphur content of the coal.

Wind power also received attention in Ethiopia [66]. Similar to studies conducted in developed countries, the CO\(_2\) emissions per kWh output were low, around 35 g CO\(_2\)/kWh.

Electricity demand in the Middle East and North African (MENA) region has increased at a rate of 6–8% in recent years. To limit the impacts of this increase, a hybrid solar and biomass power plant was evaluated in Tunisia [199]; the GWP impact was found to be 22 kg CO\(_2\)eq/MWh, with the boiler system and field having the greatest impact. Resource depletion and human toxicity were not negligible due to the solar field. Similar results were obtained in Morocco [113]. One of the solutions to promote renewables would be to retrofit existing dams to generate electricity from hydro power. This option was studied in Nigeria [125], finding corresponding values between 1.6 and 5.5 kg CO\(_2\)eq/MWh. It was highlighted that there were advantages in terms of saving on economic investments as well in that case.

Finally, the extraction of raw materials such as coal, oil or natural gas has not received as much attention, as further highlighted by A. Irhoma et al. [82] in Libya. The study showed that crude oil production and distillation had significant impacts. The impact of respiratory inorganics was also highlighted. The authors pushed for a reduction in fossil resources at refineries but also raised concerns for flaring and venting issues.

4. Discussion
4.1. The Need for an African LCI Database

As observed in several studies [26,74,87,179] and highlighted furthermore in Table 1, many of the LCA results obtained in the different studies were based on data from European-based LCI databases, namely, Ecoinvent or Gabi. Even though there has been progress in globalizing inventory processes from Ecoinvent v2 to Ecoinvent v3 [217], most of the processes are based on the situations in developed countries. Therefore, several important uncertainties may exist when using these data to evaluate African conditions, especially for the least developed African economies. To solve these limitations, the Life-Cycle Initiative has promoted the “Global LCA Data Access network” (GLAD) to encourage the compatibility between the LCI databases and share information between different countries [218]. Several datasets can be found for African countries and future research could focus on improving these datasets.

4.2. The Need for an African LCIA Method

A second comment can be made when looking at the life cycle impact assessment (LCIA) methods used in the different studies. Many of the models have been developed based on the situation in developed countries (i.e., in terms of the population, population density, meteorological conditions, etc.). This point has also been raised by M. Ghazi et al [20]. Only a few studies in our review used a global life cycle impact assessment method, namely, ReCiPe2016 [10], Impact World+ [219] or LIME3 [220]. These methods provide characterization factors for each impact that is specific to the global region.
or country. The accuracy of the damage assessment can be greatly improved; however, limitations still exist, for example, models for air pollution damage in these methods divided Africa into only a limited number of regions. Some improvements could be made to further take into account the specific socio-economic disparities between African countries in these methods.

4.3. Future Possible Topics of LCA Research

In this section, some potential research topics are raised from economic and environmental points of view. Environmental data were mainly collected from global popular databases used in LCA such as EDGARv5.0 [221] or FAOSTAT [6], economic information from OEC [5], and the world factbook from CIA [222].

A remark concerning all African countries can be raised, even though several reports from the UNEP [223] have highlighted the potential impacts of second-hand vehicles in African countries (imported mainly from Europe and the USA), there is no research paper that has focused on second-hand vehicles in Africa, despite the fact that the global LCA community has focused extensively on transport. The impact of tourism could be also studied furthermore, as the concern for sustainable tourism has been raised in recent years [224].

A description for each African country is provided in Table 2, regarding each aforementioned topic.
| Country  | Agriculture                                                                                           | Energy                                                                                       | Other                                                                                           |
|---------|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Algeria | - Wheat, one of the major crops there, was found to have a green water footprint (WF) higher than global average (3290 vs. 1277 m³/ton) [225] | - Attention could be paid to petroleum and natural gas extraction as it contributes considerably to the country’s GDP. These two sectors represent 15% of the total CO₂ emissions [221]. -Electricity is almost only produced from natural gas [19], where it represents 25% of the total CO₂ emissions [221] | - Road transport represents 25% of CO₂ emissions [221]                                           |
| Angola  | - Cassava is a major source of revenue for agriculture, where its green WF was found to be higher than the global average (819 vs. 550 m³/ton) [225] - The burning of savanna represents more than 70% of the CO₂ emissions from the agricultural sector [6] | - Oil-related extraction contributes to about 50% of the GDP [222] and about 20% of the country’s CO₂ emissions [221] | - Road transport is the top sector for CO₂ emissions, representing nearly 25% [221]             |
| Benin   | - Attention has already been paid to tomatoes as one of the major sources of agricultural revenue. A focus on cassava and yam production could be interesting, as together they represent more than 50% of the country's agricultural revenue [6] | - More than 50% of the country’s total energy supply is from biofuel and waste products [19] | - Road transport is the top sector for CO₂ emissions, accounting for nearly 75% [221]          |
| Botswana| - The country’s agriculture is not well developed. Roots and tubers account for most of the production [6] | - Nearly 100% of the electricity is produced from coal [19], where the sector represents more than 50% of the CO₂ emissions [221] | - Mining activities represent up to 25% of the country’s GDP [222], and this could be a potential research topic |
| Burkina Faso | - Sorghum and maize represent about 30% of crop revenue [6]. Their green WF was found to be two and three times higher, respectively, when compared with the global average [225] | - More than 95% of the households use solid fuels for cooking [226] | - Almost 50% of the country’s total CO₂ emissions are due to road transport [221] - Gold mining represents a major source of revenue for exports (more than 75%) [5] |
| Burundi | - Bananas and cassava together represent about 50% of the revenue from agriculture [6]. Their green water footprint was found to be higher than the global average [225] | - More than 95% of the households use solid fuels for cooking [226] | - One third of the country’s CO₂ emissions are from road transport [221] |
| Cameroon | - Exports of timber (especially to China) have been increasing in recent years (nearly 20% of the exports) [5] | - Oil production is a solid pillar of the economy [5] and it is also the highest contributor to CO₂ emissions (43%) [221] | - Road transport is the 2nd highest CO₂ emitter, accounting for nearly 25% of the total [221] |
| Country                  | Agriculture | Energy | Other                                                                 |
|-------------------------|-------------|--------|----------------------------------------------------------------------|
| Cabo Verde              | x           | x      | - The tourism industry mainly contributes to the economy [222]        |
| Central African Republic| x           |        | - Gold and diamond mining significantly contribute to the economy [5] |
| Chad                    | - The agricultural sector is reported to have the 4th highest CO₂ emissions in Africa, especially due to savanna burning [6] | - Oil is a major source of revenue (85% of the exports) [5], where the sector represents more than one third of country’s CO₂ emissions [221] | - Road transport accounts for more than one fifth of CO₂ emissions [221] |
| Comoros                 | - Coconuts are a major crop product; their green water footprint was found to be twice that of the global average [225] | x      | - Road transport contributes to nearly 50% of the emissions [221]     |
| Congo DR                | - Cassava is the major crop produced, resulting in significant land burning before plantation. The burning of savanna represents more than 80% of the CO₂ emissions from the agricultural sector [6] | - Nearly 100% of the total energy supply is from biofuel and waste products [19] | - Mining products represent an important source of revenue, especially copper and cobalt [5] |
| Djibouti                | x           |        |                                                                      |
| Egypt                   | - The use of synthetic fertilizers contributes to about one third of CO₂ emissions from the agricultural sector [6] | - Electricity is mainly produced from fossil fuels (natural gas) [19], where the sector represents almost 40% of CO₂ emissions [221] | - Road transport represents 20% of the CO₂ emissions [221] |
| Equatorial Guinea       | - Sweet potatoes and cassava are two major crops produced in the country, where their green WF was found to be four times higher than the global average [225] | - The oil industry represents an importance source of revenue (more than 80% of exports [3]) and it represents 30% of CO₂ emissions [221] | - The chemical industry represents a source of revenue for exports [5], where the sector represents 30% of country CO₂ emissions [221] |
| Eritrea                 | - Sorghum is the main crop produced, where its green WF was found with a water footprint more than twice that of the global average [225] | - Almost 100% of the electricity is produced from oil [19], where the sector accounts for more than one half of the CO₂ emissions [221] | - Road transport accounts for more than 20% of CO₂ emissions [221] |
| Eswatini                | - Sugarcane is the major crop produced in the country [6] | - About one half of the country’s CO₂ emissions are due to the electricity sector [221] | - Road transport accounts for about one third of CO₂ emissions [221] |
| Ethiopia                | - Emissions due to agriculture are reported to be the highest in Africa, especially due to manure management [6] | - About 90% of the country’s energy supply is from biofuel and waste products [226] | - Road transport accounts for about one third of CO₂ emissions [221] |
| Country       | Agriculture                     | Energy                                      | Other                                      |
|--------------|---------------------------------|---------------------------------------------|--------------------------------------------|
| Gabon        | - Cassava is one of the main crops produced [6], where its green WF was found to be higher than the global average (487 vs. 550 m³/ton) [225] | - The oil and natural gas sectors are the main sources of revenue for the country, representing about 50% of CO₂ emissions [221] | x                                          |
| Gambia       | - Groundnuts bring important revenue to agriculture; their green WF was found to be higher than the global average (3657 vs. 2469) [225] | - More than 95% of the households use solid fuels for cooking [226] | Road transport accounts for about 50% of the CO₂ emissions [221] |
| Ghana        | - The burning of savanna contributes to more than 40% of the CO₂ emissions from the agricultural sector [6] | - Oil is an important source of revenue for exports [5], where the sector accounts for about 20% of the CO₂ emissions [221] | Road transport accounts for about 40% of the CO₂ emissions [221] |
| Guinea       | - Agriculture relies on rice production [6], where its green WF was found to be about four times higher than the global average (4004 vs. 1146 m³/ton) [225] | - The electricity sector is responsible for about 20% of the CO₂ emissions [221] | - The country's growth relies on mining products, especially as it has the highest bauxite reserves in the world [222] |
| Guinea-Bissau| - Agriculture relies extensively on rice production [6], where its green WF was found to be about three times higher than the global average (3291 vs. 1146 m³/ton) [225] | - The electricity sector is responsible for about 20% of the CO₂ emissions [221] | Road transport accounts for about 50% of the CO₂ emissions [221] |
| Cote d'Ivoire| - Cocoa represents a major source of revenue [5], where the LCA results could be compared with its neighbors such as Ghana | - More than 50% of the country's electricity is produced from fossil fuels (natural gas) [19], where the sector accounts for about one third of the CO₂ emissions [221] | Road transport accounts for about one third of the CO₂ emissions [221] |
| Kenya        | - Agriculture represents one third of the GDP [222]. Tea production was assessed, and maize, potatoes, or sugarcane could be also studied | - More than 80% of households use solid fuels for cooking [226] | - Kenya is the second largest market for African vehicles [227], where the sector contributes to 50% of the total CO₂ emissions [221] |
| Lesotho      | - Potatoes and maize are the two major crops [6] | - The electricity sector accounts for about one fifth of the CO₂ emissions [221] | Road transport accounts for about 50% of the CO₂ emissions [221] |
| Liberia      | - Cassava is the main crop produced [6], where its green WF was about three times higher than the global average [225] | - Almost 100% of households use solid fuels for cooking [226] | Road transport accounts for about 40% of the CO₂ emissions [221] |
| Libya        | x                                | - The main economic resource, oil, has already received attention [82]. Apart from that, the electricity sector accounts for 40% of CO₂ emissions [221] | Road transport accounts for about 50% of the CO₂ emissions [221] |
| Madagascar   | - Rice, sugarcane, and cassava are the main agricultural products [6] and could receive more attention | - The electricity sector accounts for about 50% of the CO₂ emissions [221] | Road transport accounts for about 25% of the CO₂ emissions [221] |
| Country       | Agriculture                                                                 | Energy                                                                 | Other                                                                                                                                 |
|---------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Malawi        | - The economy relies on tobacco for exports                                   | - The electricity sector accounts for one third of the CO₂ emissions    | - Road transport accounts for one third of the CO₂ emissions                                                                       |
| Mali          | - Rice and maize, the two main crops produced [6], were found to have a green WF twice that of the global average [225] | - Almost all households use solid fuels for cooking [226]              | - Road transport and cement production each account for one third of the CO₂ emissions [221]                                        |
| Mauritania    | - Rice is the major crop produced [6]                                         | - The electricity sector accounts for about 20% of CO₂ emissions        | - Road transport accounts for 40% of the CO₂ emissions [221]                                                                       |
| Mauritius     | x                                                                              | - Fossil fuels represent 50% of electricity production [19], accounting for more than 60% of CO₂ emissions [221] | - Road transport accounts for 25% of the CO₂ emissions [221]                                                                         |
| Morocco       | - The total energy consumption for agriculture is the third highest in Africa (more than 50,000 terajoules [6]) | - The electricity sector accounts for more than one third of the CO₂ emissions [221], especially due to coal power plants [19] | - Morocco was also the first destination in Africa for tourism (2018 data [228]), and the impact of the tourism sector could receive attention |
| Mozambique    | - Cassava is the major crop produced, where its green WF was found to be twice that of the global average (1077 vs. 500 m³/ton) [225] | - More than 95% of households use solid fuels for cooking [226]         | - The country relies on mineral fuels (coal) and aluminum for exports [5], and extraction processes could be further analyzed           |
| Namibia       | - More than 50% of the CO₂ emissions related to agricultural sector are due to the burning of savanna [6] | x                                                                       | - The country relies on mineral extraction, such as diamond and uranium extraction.                                                   |
| Niger         | - Millet is the main crop produced [5], where its green WF was found to be two times higher than the global average (10,330 vs. 4306 m³/ton) [225] | - Nearly 100% of the electricity is produced from fossil fuels (coal and oil) [19], where the sector accounts for more than 20% of the country’s CO₂ emissions [221] | - Road transport accounts for 50% of the CO₂ emissions [221]                                                                         |
| Nigeria       | - Agriculture represents the second highest CO₂ emissions in Africa [221], Cassava has received attention, and in addition, yams and maize could be examined as other major crops [6] | - Oil is a major source of revenue for the country [5], where it represents 20% of the country’s CO₂ emissions [221] | - Road transport accounts for about one third of the CO₂ emissions [221]                                                           |
| Republic of Congo | - Cassava and sugarcane are the two main crops [6]                           | - Oil a major source of revenue for exports [5], where the sector is responsible for 50% of the CO₂ emissions [221] | - Road transport accounts for about one third of the CO₂ emissions [221]                                                           |
| Rwanda        | - The country mainly relies on agriculture, especially bananas and cassava [6] | - Almost all households use solid fuels for cooking [226]              | - Road transport accounts for about 40% of the CO₂ emissions [221]                                                                     |
| Sao tome & Principe | - Cocoa beans are a major source of revenue for exports [5]              | x                                                                       | x                                                                                                                                   |
| Senegal       | - Rice and groundnuts are the two main crops [6]                             | - Most of the electricity is produced from oil, where the sector contributes to about one quarter of the CO₂ emissions [221] | - Gold and phosphoric mining-related revenues have been increasing in recent years [5] and could lead to an increase in environmental impacts |
Table 2. Cont.

| Country       | Agriculture                          | Energy                                      | Other                                                      |
|---------------|--------------------------------------|---------------------------------------------|------------------------------------------------------------|
| Seychelles    | $x$                                   | - Electricity accounts for about one quarter of CO$_2$ emissions [221] | - Similar to Cabo Verde, the economy is mostly driven by tourism, and this could be relevant for study |
| Sierra Leone  | - Rice is the major crop produced in the country [6] | - Nearly 100% of the households use solid fuels for cooking [226] | - Mining products (titanium and aluminum) drive exports [5] |
| Somalia       | - Revenues are mainly from livestock [6] (sheep and goats) | - Nearly 100% of the households use solid fuels for cooking [226] | - Road transport accounts for about 50% of the CO$_2$ emissions [221] |
| South Africa  | - The most produced crops (maize and sugarcane) have already been paid attention | - Electricity, mostly produced from coal [11], contributes to 50% of the CO$_2$ emissions [221] | - Road transport accounts for about 10% of the CO$_2$ emissions [221] |
| South Sudan   | $x$                                   | - Oil production is a major driver of the economy [5] | $x$                                                        |
| Sudan         | - The agricultural sector is the 3rd largest for CO$_2$ emissions in Africa, with sugarcane, sorghum, and millet as major crops. - Sudan is also the largest exporter of Arabic gum [222] | - About half of the electricity is produced from oil [11], where the sector accounts for about 20% of the CO$_2$ emissions [221] | - Road transport accounts for about 50% of the CO$_2$ emissions [221] |
| Tanzania      | - Maize is the main crop produced [6], where its green WF was found to be double the global average | - More than 95% of the households use solid fuels for cooking [226] | - Road transport accounts for about 50% of the CO$_2$ emissions [221] |
| Togo          | - The economy relies on agriculture (yams, cassava, maize, sorghum) [6] | - The country has been increasing its production of oil for exports [5] | - Road transport accounts for more than 50% of the CO$_2$ emissions [221] |
| Tunisia       | - The agricultural sector has already received attention, where its energy usage was found to be the fourth highest in Africa [6] | - Electricity is mostly produced from natural gas [19], where the sector accounts for about one third of CO$_2$ emissions [221] | - Road transport account for about one fifth of the CO$_2$ emissions [221] |
| Uganda        | - The economy mostly relies on agriculture, especially coffee [5] | - More than 95% of the households use solid fuels for cooking [226] | - Gold mining operations have been increasing in recent years [5] |
| Zambia        | - Maize and cassava are the two main crops produced, where their green WFs were higher than global averages [225] | - More than 80% of the households use solid fuels for cooking [226] | - The mining industry (mostly copper) brings significant revenues [5] |
| Zimbabwe      | - Sugarcane, Maize, and Cassava are the major crops [6] and tobacco also brings important revenue from exports [5] | - About 40% of the electricity is produced from coal [11], where the sector is responsible for more than one half of the CO$_2$ emissions [221] | - The economy depends on mining (especially gold) [5] |
5. Conclusions

A total of 199 peer-reviewed LCA articles were found for Africa. The interest in LCA for the continent has been growing in the last ten years, but it remains far less than in other countries, including developing countries, located in Asia such as Thailand. The most active African countries are South Africa (43), Egypt (23), and Tunisia (19). It was observed that several countries (especially those in central Africa) were not paid attention. For example, a country such as the DR Congo, whose population may exceed 200 million in 2050, has not yet been the subject of research. With the predicted economic and population growth, the already existing environmental impacts might increase in Africa in the near future. The number of LCA researchers based in Africa is still limited, and it appears important to prioritize education and training of the life cycle thinking for the continent.

African LCA has mainly focused on agricultural products and energy, representing almost half of the research topics. Fisheries, fruits, and vegetables have received considerable attention as well as biofuel. However, several key products of the African economy were not paid attention such as second-hand vehicles or natural resources (oil, natural gas, mining products, etc.). With the African Continental Free Trade Area (AfCFTA) commencing as of 1 January 2021, trade between African countries might intensify, and the need for sustainable production could become very important.

As shown in Table 1, one of this review’s key messages is that research has been mainly conducted with LCI databases that are not specific to African countries. The usage of global LCIA methods also remains scarce. Several key economic sectors for African countries have not yet been assessed.

This lack of tools specific to African countries to conduct LCA could lead to uncertainties in consequent results. Future research could probably focus on developing an LCI database that is specific to the African continent and on improving the resolution of impact assessment models to include a higher number of African regions.

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## Table A1.

Gross domestic product (GDP) [224] of African countries and articles per sector (the sum of the different columns is not necessarily always equal to the sum of the last column, as, for example, “reviews” cannot be inserted into any sector).

| Country                      | Total GDP (PPP Million USD) | Share of GDP, Agriculture (%) [Nb of Articles] | Share of GDP, Industry (%) [Nb of Articles] | Share of GDP, Services (%) [Nb of Articles] | Total Number of Research Articles |
|------------------------------|----------------------------|-----------------------------------------------|---------------------------------------------|---------------------------------------------|----------------------------------|
| Algeria                      | 630,000                    | 13.3 [1]                                      | 39.3 [4]                                     | 47.4 [0]                                    | 16                               |
| Angola                       | 193,600                    | 10.2 [0]                                      | 61.4 [0]                                     | 26.4 [0]                                    | 0                                |
| Benin                        | 25,390                     | 26.1 [2]                                      | 22.8 [0]                                     | 51.1 [0]                                    | 1                                |
| Botswana                     | 39,010                     | 1.8 [0]                                       | 27.5 [0]                                     | 70.6 [0]                                    | 0                                |
| Burkina Faso                 | 35,850                     | 31.0 [0]                                      | 23.9 [4]                                     | 44.9 [0]                                    | 4                                |
| Burundi                      | 807                        | 39.5 [0]                                      | 16.4 [0]                                     | 44.2 [0]                                    | 0                                |
| Cameroon                     | 89,540                     | 16.7 [1]                                      | 26.5 [3]                                     | 56.8 [1]                                    | 5                                |
| Cape Verde                   | 3777                       | 8.9 [0]                                       | 17.5 [0]                                     | 73.7 [0]                                    | 0                                |
| Central African Republic     | 3390                       | 43.2 [0]                                      | 16.0 [0]                                     | 40.8 [0]                                    | 0                                |
| Chad                         | 28,620                     | 52.3 [0]                                      | 14.7 [0]                                     | 33.1 [0]                                    | 0                                |
| Comoros                      | 1319                       | 47.7 [0]                                      | 11.8 [0]                                     | 40.5 [0]                                    | 0                                |
| Democratic Republic of the Congo | 68,600               | 19.7 [0]                                      | 43.6 [0]                                     | 36.7 [0]                                    | 0                                |
| Djibouti                     | 3640                       | 2.4 [0]                                       | 17.3 [0]                                     | 80.2 [0]                                    | 0                                |
| Egypt                        | 1,204,000                  | 11.7 [4]                                      | 34.3                                         | 54                                          | 13                               |
| Equatorial Guinea            | 31,520                     | 2.5 [0]                                       | 54.6 [0]                                     | 42.9 [0]                                    | 0                                |
| Eritrea                      | 9402                       | 11.7 [0]                                      | 29.6 [0]                                     | 58.7 [0]                                    | 0                                |
| Eswatini                     | 11,600                     | 6.5 [0]                                       | 45.0                                         | 48.6 [0]                                    | 0                                |
| Ethiopia                     | 200,600                    | 34.8 [2]                                      | 21.6 [2]                                     | 43.6                                        | 4                                |
| Gabon                        | 36,660                     | 5.0 [0]                                       | 44.7 [0]                                     | 50.4 [0]                                    | 0                                |
| Gambia                       | 5556                       | 20.4 [0]                                      | 14.2 [0]                                     | 65.4 [0]                                    | 0                                |
| Ghana                        | 134,000                    | 18.3 [4]                                      | 24.5 [4]                                     | 57.2 [0]                                    | 8                                |
| Guinea                       | 27,970                     | 19.8 [0]                                      | 32.1 [0]                                     | 48.1 [0]                                    | 0                                |
| Guinea-Bissau                | 3171                       | 50.0 [0]                                      | 13.1 [0]                                     | 36.9 [0]                                    | 0                                |
| Ivory Coast                  | 97,160                     | 20.1 [0]                                      | 26.6 [1]                                     | 53.3 [0]                                    | 1                                |
| Kenya                        | 163,700                    | 34.5                                          | 17.8                                         | 47.5                                        | 7                                |
| Lesotho                      | 6656                       | 5.8 [0]                                       | 39.2 [0]                                     | 54.9 [1]                                    | 1                                |
| Liberia                      | 6112                       | 34.0 [0]                                      | 13.8 [0]                                     | 52.2 [0]                                    | 0                                |
| Libya                        | 61,970                     | 1.3 [0]                                       | 52.3 [2]                                     | 46.4 [0]                                    | 2                                |
| Madagascar                   | 39,850                     | 24.0 [0]                                      | 19.5 [1]                                     | 56.4 [0]                                    | 2                                |
| Malawi                       | 22,420                     | 28.6 [1]                                      | 15.4 [2]                                     | 56 [0]                                      | 3                                |
| Mali                         | 41,220                     | 41.8 [1]                                      | 18.1 [1]                                     | 40.5 [1]                                    | 6                                |
| Mauritania                   | 17,280                     | 27.8 [1]                                      | 29.3 [1]                                     | 42.9 [0]                                    | 2                                |
| Mauritius                    | 28,270                     | 4.2 [0]                                       | 21.8 [2]                                     | 74.1 [9]                                    | 13                               |
| Morocco                      | 298,600                    | 14.4 [0]                                      | 29.5 [6]                                     | 56.5 [1]                                    | 11                               |
| Mozambique                   | 37,090                     | 23.9 [0]                                      | 19.3 [2]                                     | 56.8 [0]                                    | 2                                |
| Country                        | Total GDP (PPP, Million USD) | Share of GDP, Agriculture (%) [Nb of Articles] | Share of GDP, Industry (%) [Nb of Articles] | Share of GDP, Services (%) [Nb of Articles] | Total Number of Research Articles |
|-------------------------------|------------------------------|-----------------------------------------------|---------------------------------------------|---------------------------------------------|-----------------------------------|
| Namibia                       | 26,600                       | 6.7 [0]                                       | 26.3 [0]                                   | 67 [0]                                      | 0                                 |
| Niger                         | 21,860                       | 41.6 [0]                                      | 19.5 [0]                                   | 38.7 [0]                                   | 0                                 |
| Nigeria                       | 1,121,000                    | 21.1                                          | 22.5                                       | 56.4                                        | 19                                |
| Republic of the Congo         | 29,390                       | 9.3 [0]                                       | 51 [0]                                     | 39.7 [0]                                   | 0                                 |
| Rwanda                        | 24,680                       | 30.9 [1]                                      | 17.6 [0]                                   | 51.5 [0]                                   | 1                                 |
| São Tomé and Principe         | 686                          | 11.8 [0]                                      | 14.8 [0]                                   | 73.4 [0]                                   | 0                                 |
| Senegal                       | 54,800                       | 16.9 [1]                                      | 24.3 [0]                                   | 58.8 [0]                                   | 1                                 |
| Seychelles                    | 2750                         | 2.5 [0]                                       | 13.8 [0]                                   | 83.7 [0]                                   | 0                                 |
| Sierra Leone                  | 11,550                       | 60.7 [0]                                      | 6.5 [0]                                    | 32.9 [0]                                   | 0                                 |
| Somalia                       | 20,440                       | 60.2 [0]                                      | 7.4 [0]                                    | 32.5 [1]                                   | 1                                 |
| South Africa                  | 767,200                      | 2.8                                           | 29.7                                       | 67.5                                       | 21                                |
| South Sudan                   | - [0]                        | - [0]                                         | - [0]                                      | - [0]                                       | 0                                 |
| Sudan                         | 177,400                      | 39.6 [0]                                      | 2.6 [0]                                    | 57.8 [0]                                   | 0                                 |
| Tanzania                      | 162,500                      | 23.4 [1]                                      | 28.6 [6]                                   | 47.6 [0]                                   | 7                                 |
| Togo                          | 12,970                       | 28.8 [0]                                      | 21.8 [0]                                   | 49.8 [0]                                   | 0                                 |
| Tunisia                       | 137,700                      | 10.1 [12]                                     | 26.2 [5]                                   | 63.8 [1]                                   | 19                                |
| Uganda                        | 89,190                       | 28.2 [1]                                      | 21.1 [1]                                   | 50.7 [4]                                   | 7                                 |
| Zambia                        | 68,930                       | 7.5 [1]                                       | 35.3 [1]                                   | 57 [0]                                      | 2                                 |
| Zimbabwe                      | 34,270                       | 12 [0]                                        | 22.2 [5]                                   | 65.8 [2]                                   | 7                                 |
Figure A1. Correlation between the GDP (PPP) with the number of LCA research articles concerning each African country.
| Country [Ref.] | System Boundaries                  | Allocation                      | Institution of the First Author              | Location of the First Author |
|---------------|------------------------------------|---------------------------------|---------------------------------------------|-------------------------------|
| Algeria [20]  | Cradle to grave                    | No indication/no allocation     | EOST                                        | France                        |
| Algeria [21]  | Cradle to gate                     | No indication/no allocation     | Boumerdes University                        | Algeria                       |
| Algeria [22]  | Cradle to grave                    | No indication/no allocation     | Boumerdes University                        | Algeria                       |
| Algeria [23]  | Cradle to grave                    | No indication/no allocation     | University of Boumerdes                    | Algeria                       |
| Algeria [24]  | Cradle to gate                     | No indication/no allocation     | BADJI Mokhtar University                    | Algeria                       |
| Algeria [25]  | Cradle to grave                    | No indication/no allocation     | University of Boumerdes                    | Algeria                       |
| Algeria [26]  | Cradle to gate                     | No indication/no allocation     | ENSSMAL                                     | Algeria                       |
| Algeria [27]  | Cradle to grave                    | No indication/no allocation     | University Saad Dahlab                      | Algeria                       |
| Algeria [28]  | Well-to-Tank                       | No indication/no allocation     | Ecole Nationale Polytechnique               | Algeria                       |
| Algeria [29]  | Cradle to grave                    | No indication/no allocation     | Bougara University                          | Algeria                       |
| Benin [30]    | Cradle to gate                     | No indication/no allocation     | CIRAD                                        | France                        |
| Benin [31]    | Cradle to gate                     | No indication/no allocation     | CIRAD                                        | France                        |
| Burkina Faso [32] | Cradle to grave                  | No indication/no allocation     | Escola Tècnica Superior d’Enginyeries Industrial | Spain                        |
| Burkina Faso [33] | Well-to-Tank                      | energy allocation               | Boumerdes University                        | Germany                       |
| Burkina Faso [34] | Cradle to site                    | No indication/no allocation     | Universitat Politècnica de Catalunya (UPC) | Spain                        |
| Cameroon [35] | Well-to-Wheel                      | No indication/no allocation     | KU Leuven                                   | Belgium                       |
| Cameroon [36] | Cradle to grave                    | No indication/no allocation     | University of Yaoundé                       | Cameroon                      |
| Cameroon [37] | Cradle to gate                     | Economic allocation             | INRA                                        | France                        |
| Cameroon [38] | end-of-life                        | No indication/no allocation     | University of Yaoundé                       | Cameroon                      |
| Cameroon [39] | Well-to-Tank                       | energy allocation               | University of Udine                         | Italy                         |
| Egypt [40]    | Cradle to site/end-of-life         | No indication/no allocation     | Environment and Climate Research Institute, Egypt | Egypt                        |
| Egypt [41]    | end-of-life                        | No indication/no allocation     | National Water Research Center, Egypt       | Egypt                         |
| Egypt [42]    | Not applicable                     | No indication/no allocation     | E-JUST                                      | Egypt                         |
| Egypt [43]    | Cradle to grave                    | No indication/no allocation     | E-JUST                                      | Egypt                         |
| Egypt [44]    | Not applicable                     | No indication/no allocation     | E-JUST                                      | Egypt                         |
| Country [Ref.] | System Boundaries | Allocation                     | Institution of the First Author                          | Location of the First Author |
|---------------|-------------------|--------------------------------|---------------------------------------------------------|-----------------------------|
| Egypt [45]    | Cradle to gate    | Economic allocation           | Universita Politecnica delle Marche                     | Italy                       |
| Egypt [46]    | Not applicable    | No indication/no allocation   | E-JUST                                                   | Egypt                       |
| Egypt [47]    | Cradle to grave   | No indication/no allocation   | Riga Technical University                               | Latvia                      |
| Egypt [48]    | end-of-life       | No indication/no allocation   | E-JUST                                                   | Egypt                       |
| Egypt [49]    | Cradle to grave   | No indication/no allocation   | Parthenope University of Naples                          | Italy                       |
| Egypt [50]    | Cradle to gate    | Mass and economic allocation  | WorldFish                                                | Malaysia                    |
| Egypt [51]    | Not applicable    | No indication/no allocation   | Menoufia University                                     | Egypt                       |
| Egypt [52]    | Not applicable    | No indication/no allocation   | E-JUST                                                   | Egypt                       |
| Egypt [53]    | Cradle to gate    | Mass and energy allocation    | E-JUST                                                   | Egypt                       |
| Egypt [54]    | Cradle to gate    | No indication/no allocation   | Alexandria University                                    | Egypt                       |
| Egypt [55]    | Cradle to gate    | No indication/no allocation   | E-JUST                                                   | Egypt                       |
| Egypt [56]    | end-of-life       | No indication/no allocation   | Alexandria University                                    | Egypt                       |
| Egypt [57]    | Cradle to gate    | No indication/no allocation   | E-JUST                                                   | Egypt                       |
| Egypt [58]    | Cradle to grave   | No indication/no allocation   | Ministry of Petroleum and Mineral Resources, Alexandria, | Egypt                       |
| Egypt [59]    | end-of-life       | No indication/no allocation   | Mansoura University                                      | Egypt                       |
| Egypt [60]    | end-of-life       | No indication/no allocation   | Mansoura University                                      | Egypt                       |
| Egypt [61]    | Cradle to gate    | No indication/no allocation   | Cairo University                                          | Egypt                       |
| Egypt [62]    | Cradle to gate    | No indication/no allocation   | University of Siena                                       | Italy                       |
| Ethiopia [63] | Cradle to gate    | No indication/no allocation   | Wageningen University                                    | Netherlands                 |
| Ethiopia [64] | Cradle to grave   | No indication/no allocation   | Universitat Hohenheim                                     | Germany                     |
| Ethiopia [65] | Cradle to gate    | Economic allocation           | Wageningen University                                    | Netherlands                 |
| Ethiopia [66] | Cradle to grave   | Ecoinvent 3-allocation, default unit | Addis Ababa University                                 | Ethiopia                     |
| Ghana [67]   | Cradle to gate    | No indication/no allocation   | University of Ghana                                      | Ghana                       |
| Ghana [68]   | Cradle to gate    | No indication/no allocation   | The Hong Kong Polytechnic University                     | Hong Kong                   |
| Ghana [69]   | Cradle to gate    | Mass and energy allocation    | University of Genoa                                       | Italy                       |
| Ghana [70]   | Cradle to gate    | No indication/no allocation   | Wageningen University                                    | Netherlands                 |
| Ghana [71]   | Cradle to gate    | No indication/no allocation   | University of Ghana                                      | Ghana                       |
| Country [Ref.]  | System Boundaries       | Allocation                    | Institution of the First Author                                           | Location of the First Author |
|-----------------|--------------------------|-------------------------------|---------------------------------------------------------------------------|------------------------------|
| Ghana [72]      | Cradle to grave          | No indication/no allocation   | Curtin University                                                         | Australia                    |
| Ghana [73]      | Cradle to gate           | Physical and economical allocation | Wageningen University                                                   | Netherlands                  |
| Ghana [74]      | Cradle to gate           | No indication/no allocation   | Kwame Nkrumah University of Science & Technology                         | Ghana                        |
| Ivory Coast [75]| Well-to-Tank energy allocation |                             | Universite de Toulouse                                                   | France                       |
| Kenya [76]      | Cradle to gate           | No indication/no allocation   | Marks and Spencer                                                        | UK                           |
| Kenya [77]      | Cradle to grave          | No indication/no allocation   | Technical University of Denmark                                          | Denmark                      |
| Kenya [78]      | Cradle to gate           | No indication/no allocation   | University of California                                                 | USA                          |
| Kenya [79]      | Cradle to gate           | No indication/no allocation   | University of Michigan                                                   | USA                          |
| Kenya [80]      | Gate to grave            | No indication/no allocation   | Umeå University                                                          | Sweden                       |
| Libya [81]      | Cradle to grave          | No indication/no allocation   | Nottingham Trent University                                             | UK                           |
| Libya [82]      | Cradle to grave          | No indication/no allocation   | The Higher Institute of Polytechnic Professions                          | Libya                        |
| Madagascar [83]| Cradle to grave?         | No indication/no allocation   | University of Antananarivo                                                | Madagascar                   |
| Madagascar [84]| Cradle to gate           | No indication/no allocation   | Université de la Réunion                                                 | France                       |
| Malawi [85]     | Gate to gate             | No indication/no allocation   | Stellenbosch University                                                  | South Africa                 |
| Malawi [86]     | Cradle to site           | No indication/no allocation   | Edinburgh Napier University                                              | UK                           |
| Malawi [87]     | Cradle to gate           | Economic and mass allocation  | University of Exeter                                                     | UK                           |
| Mali [88]       | Cradle to grave          | No indication/no allocation   | Higher Technical Institute, Cyprus                                        | Cyprus                       |
| Mali [89]       | Cradle to gate           | No indication/no allocation   | KU Leuven                                                                | Belgium                      |
| Mali [90]       | Cradle to gate           | No indication/no allocation   | KU Leuven                                                                | Belgium                      |
| Mali [91]       | Cradle to gate           | No indication/no allocation   | University of South Florida                                              | USA                          |
| Mali [92]       | Cradle to gate           | Economic allocation           | CIRAD                                                                     | France                       |
| Mauritania [93]| Cradle to gate           | Mass allocation               | University of Santiago de Compostela                                     | Spain                        |
| Mauritania [94]| Cradle to gate           | No indication/no allocation   | Instituto Eduardo Torroja de ciencias de la construcción                | Spain                        |
| Mauritius [99] | end-of-life              | No indication/no allocation   | University of Mauritius                                                  | Mauritius                    |
| Mauritius [100]| Cradle to grave          | Economic allocation           | University of Mauritius                                                  | Mauritius                    |
| Mauritius [101]| Cradle to grave          | No indication/no allocation   | University of Mauritius                                                  | Mauritius                    |
| Country [Ref.] | System Boundaries | Allocation | Institution of the First Author | Location of the First Author |
|----------------|-------------------|------------|---------------------------------|-----------------------------|
| Mauritius [102] | Cradle to grave   | No indication/no allocation | University of Mauritius | Mauritius |
| Mauritius [103] | Cradle to site    | Economic and mass allocation | University of Mauritius | Mauritius |
| Mauritius [104] | end-of-life       | No indication/no allocation | Sotravic Ltd | Mauritius |
| Mauritius [95]  | Cradle to grave   | Economic allocation     | University of Mauritius | Mauritius |
| Mauritius [96]  | end-of-life       | No indication/no allocation | University of Mauritius | Mauritius |
| Mauritius [97]  | Cradle to site    | Economic allocation     | University of Mauritius | Mauritius |
| Mauritius [98]  | Cradle to grave   | No indication/no allocation | University of Mauritius | Mauritius |
| Morocco [105]   | Cradle to gate    | Mass allocation         | ADEME              | France |
| Morocco [106]   | Cradle to gate    | No indication/no allocation | CIRAD             | France |
| Morocco [107]   | Cradle to gate    | Economic allocation     | CIRAD              | France |
| Morocco [108]   | Cradle to gate    | No indication/no allocation | Universidad Politécnica de Madrid | Spain |
| Morocco [109]   | Cradle to grave   | No indication/no allocation | INES              | France |
| Morocco [110]   | Cradle to gate    | No indication/no allocation | CIRAD              | France |
| Morocco [111]   | Cradle to grave   | No indication/no allocation | University of Ljubljana | Slovenia |
| Morocco [112]   | Cradle to gate    | No indication/no allocation | Abdelmalek Essaadi University | Morocco |
| Morocco [113]   | Cradle to grave   | Economic allocation     | CIEMAT             | Spain |
| Morocco [114]   | Cradle to grave?  | No indication/no allocation | Mohammed V University | Morocco |
| Morocco [115]   | Cradle to gate    | No indication/no allocation | Mohammadia School of Engineering | Morocco |
| Mozambique [116]| Well-to-Wheel      | Mass allocation         | Chalmers University of Technology | Sweden |
| Mozambique [117]| Cradle to site    | Mass allocation         | Swedish University of Agricultural Sciences | Morocco |
| Nigeria [118]   | Cradle to grave   | No indication/no allocation | University of Manchester | UK |
| Nigeria [119]   | Cradle to grave?  | No indication/no allocation | Iowa State University | USA |
| Nigeria [120]   | Cradle to gate    | No indication/no allocation | Covenant University | Nigeria |
| Nigeria [121]   | end-of-life       | No indication/no allocation | National Water Quality Reference Laboratory Minna | Nigeria |
| Nigeria [122]   | Well-to-Wheel      | Mass allocation         | Cranfield University | UK |
| Nigeria [123]   | Gate to gate      | No indication/no allocation | University of Ibadan | Nigeria |
| Nigeria [124]   | Cradle to grave   | No indication/no allocation | University of Tlemcen | Algeria |
| Country [Ref.]                      | System Boundaries  | Allocation                | Institution of the First Author                          | Location of the First Author       |
|-----------------------------------|--------------------|---------------------------|----------------------------------------------------------|-----------------------------------|
| Nigeria [125]                     | Cradle to grave    | No indication/no allocation | Hohai University                                        | China                             |
| Nigeria [126]                     | Cradle to grave    | No indication/no allocation | Nigerian Stored Products Research Institute              | Nigeria                           |
| Nigeria [127]                     | Cradle to gate     | No indication/no allocation | Landmark University                                      | Nigeria                           |
| Nigeria [128]                     | Cradle to gate     | No indication/no allocation | Adeleke University                                       | Nigeria                           |
| Nigeria [129]                     | Cradle to grave    | No indication/no allocation | The University of Manchester                              | UK                                |
| Nigeria [130]                     | Cradle to gate     | No indication/no allocation | Ladoke Akintola University of Technology                 | Nigeria                           |
| Nigeria, ghanana, ivory coast [13]| Not applicable     | No indication/no allocation | The University of Manchester                              | South Africa                      |
| Rwanda [131]                      | Cradle to gate     | Mass allocation            | CIRAD                                                    | France                            |
| Senegal [132]                     | Cradle to gate     | Economic allocation        | The Swedish Institute for Food and Biotechnology          | Sweden                            |
| Somalia [133]                     | Cradle to grave    | Mass allocation            | University of Siena                                       | Italy                             |
| South Africa [134]                | Not applicable     | No indication/no allocation | University of Pretoria                                    | South Africa                      |
| South Africa [135]                | Cradle to gate     | Mass allocation            | University of Pretoria                                    | South Africa                      |
| South Africa [136]                | Cradle to gate     | No indication/no allocation | University of Natal                                       | South Africa                      |
| South Africa [137]                | Not applicable     | No indication/no allocation | University of Pretoria                                    | South Africa                      |
| South Africa [138]                | Cradle to site     | No indication/no allocation | University of Pretoria,                                  | South Africa                      |
| South Africa [139]                | Cradle to grave    | No indication/no allocation | University of KwaZulu-Natal                               | South Africa                      |
| South Africa [140]                | Cradle to gate     | No indication/no allocation | CSIR, South Africa                                       | South Africa                      |
| South Africa [141]                | Cradle to grave    | No indication/no allocation | Huawei Technologies CO., Ltd                              | China                             |
| South Africa [142]                | end-of-life        | Mass allocation            | University of Cape Town                                   | South Africa                      |
| South Africa [143]                | Cradle to gate     | No indication/no allocation | University of Pretoria                                    | South Africa                      |
| South Africa [144]                | Cradle to gate     | No indication/no allocation | University of Catania                                     | Italy                             |
| South Africa [145]                | Well-to-Wheel      | Economic allocation        | University of Stellenbosch                                | South Africa                      |
| South Africa [146]                | Cradle to gate     | Mass allocation            | University of KwaZulu-Natal                               | South Africa                      |
| South Africa [147]                | Not applicable     | No indication/no allocation | University of Johannesburg                               | South Africa                      |
| South Africa [148]                | Cradle to grave    | No indication/no allocation | University of Cape Town                                   | South Africa                      |
| South Africa [149]                | Cradle to gate     | Economic allocation        | Stellenbosch University                                   | South Africa                      |
| South Africa [150]                | Cradle to grave    | Physical allocation        | Stellenbosch University                                   | South Africa                      |
### Table A2. Cont.

| Country [Ref.] | System Boundaries | Allocation | Institution of the First Author | Location of the First Author |
|----------------|-------------------|------------|----------------------------------|------------------------------|
| South Africa [151] | Cradle to gate | No indication/no allocation | Zurich University of Applied Sciences | Swiss                        |
| South Africa [152] | Cradle to gate | Mass allocation | University of Cape Town | South Africa                  |
| South Africa [153] | Cradle to gate | Economic and energy allocation | Stellenbosch University | South Africa                  |
| South Africa [154] | Cradle to gate | Economic allocation | University of Stellenbosch | South Africa                  |
| South Africa [155] | Cradle to gate | Economic and energy allocation | University of Stellenbosch | South Africa                  |
| South Africa [156] | Cradle to gate | Economic allocation | University of Stellenbosch | South Africa                  |
| South Africa [157] | Cradle to gate | No indication/no allocation | Institute of Electronic Structure & Laser | Greece                       |
| South Africa [158] | Cradle to gate | No indication/no allocation | University of Johannesburg | South Africa                  |
| South Africa [16]  | Not applicable | No indication/no allocation | University of the Witwatersrand | South Africa                  |
| South Africa [159] | Cradle to gate | No indication/no allocation | University of Johannesburg | South Africa                  |
| South Africa [160] | Cradle to gate | No indication/no allocation | University of the Witwatersrand | South Africa                  |
| South Africa [161] | Cradle to grave | No indication/no allocation | Cranfield University | UK                           |
| South Africa [162] | Well-to-Wheel | Mass allocation | University of Johannesburg | South Africa                  |
| South Africa [163] | Well-to-Tank | No indication/no allocation | University of Johannesburg | South Africa                  |
| South Africa [164] | Cradle to gate | No indication/no allocation | University of KwaZulu-Natal | South Africa                  |
| South Africa [165] | Not applicable | No indication/no allocation | University of Johannesburg | South Africa                  |
| South Africa [166] | Cradle to grave | No indication/no allocation | Mount Royal University Calgary | Canada                       |
| South Africa [167] | Cradle to grave | Mass allocation | University of Cape Town | South Africa                  |
| South Africa [168] | Cradle to gate | No indication/no allocation | Tshwane University of Technology | South Africa                  |
| South Africa [169] | Cradle to gate | No indication/no allocation | South African Sugarcane Research Institute | South Africa                  |
| South Africa [170] | Cradle to gate | Mass allocation | KU Leuven | Belgium                       |
| South Africa [171] | Cradle to gate | No indication/no allocation | University of Cape Town | South Africa                  |
| South Africa [172] | Cradle to gate | No indication/no allocation | University of Cape Town | South Africa                  |
| South Africa [173] | Well-to-Wheel | Economic allocation | University of Cambridge | UK                           |
| South Africa [174] | Cradle to gate | No indication/no allocation | Stellenbosch University | South Africa                  |
| South Africa [175] | Cradle to gate | Mass allocation | University of Natal | South Africa                  |
| Country [Ref.] | System Boundaries | Allocation | Institution of the First Author | Location of the First Author |
|---------------|-------------------|------------|---------------------------------|-----------------------------|
| Tanzania [176] | Cradle to grave   | No indication/no allocation | University of Dar es Salaam | Tanzania                     |
| Tanzania [177] | Cradle to gate    | No indication/no allocation | King Mongkut’s University of Technology | Thailand                   |
| Tanzania [178] | Well-to-Wheel      | energy allocation | University of Dar es Salaam | Tanzania                     |
| Tanzania [179] | Cradle to site    | No indication/no allocation | Tropical Pesticides Research Institute | Tanzania                   |
| Tanzania [180] | Cradle to gate    | No indication/no allocation | Yara International | Germany                     |
| Tanzania [181] | Not applicable    | No indication/no allocation | Tropical Pesticides Research Institute | Tanzania                   |
| Tanzania [182] | Cradle to gate    | No indication/no allocation | Research Institute of Electric Power Industry, Japan | Japan                       |
| Tunisia [183]  | Not applicable    | No indication/no allocation | CNRS | France                       |
| Tunisia [184]  | Cradle to gate    | No indication/no allocation | Université de Monastir | Tunisia                     |
| Tunisia [185]  | Cradle to gate    | No indication/no allocation | University of Sfax | Tunisia                     |
| Tunisia [186]  | Cradle to gate    | No indication/no allocation | Universitat Autònoma de Barcelona | Spain                      |
| Tunisia [187]  | Cradle to grave?  | No indication/no allocation | IRSTEA | France                       |
| Tunisia [188]  | Cradle to gate    | No indication/no allocation | Institut National des Sciences Appliquée Technologie | Tunisia                   |
| Tunisia [189]  | Cradle to gate    | No indication/no allocation | Université de Carthage | Tunisia                     |
| Tunisia [190]  | Cradle to gate    | No indication/no allocation | Université de Carthage | Tunisia                     |
| Tunisia [191]  | Cradle to gate    | No indication/no allocation | Université de Carthage | Tunisia                     |
| Tunisia [192]  | Cradle to gate    | No indication/no allocation | National School of Engineers of Gabes | Tunisia                   |
| Tunisia [193]  | Cradle to gate    | No indication/no allocation | Gabes University | Tunisia                     |
| Tunisia [194]  | Cradle to gate    | No indication/no allocation | Université de Carthage | Tunisia                     |
| Tunisia [195]  | Cradle to gate    | No indication/no allocation | CIRAD | France                       |
| Tunisia [196]  | Cradle to grave?  | No indication/no allocation | CIRAD | France                       |
| Tunisia [197]  | Cradle to gate    | No indication/no allocation | Université de Gabès | Tunisia                     |
| Tunisia [198]  | Cradle to grave   | No indication/no allocation | CIEMAT | Spain                        |
| Tunisia [199]  | Cradle to grave   | Economic allocation | CIEMAT | Spain                        |
| Tunisia [200]  | Cradle to gate    | No indication/no allocation | (IFAPA) | Spain                       |
| Tunisia [201]  | Cradle to gate    | No indication/no allocation | Cranfield University | UK                         |
| Country [Ref.] | System Boundaries         | Allocation                        | Institution of the First Author                                    | Location of the First Author |
|----------------|---------------------------|-----------------------------------|----------------------------------------------------------------------|------------------------------|
| Uganda [202]   | Cradle to grave           | No indication/no allocation        | Makerere University                                                  | Uganda                       |
| Uganda [203]   | end-of-life               | No indication/no allocation        | National Water & Sewerage Corporation, Uganda                        | Uganda                       |
| Uganda [204]   | Cradle to grave           | No indication/no allocation        | University of Hohenheim                                             | Germany                      |
| Uganda [205]   | Cradle to gate            | No indication/no allocation        | University of South Florida                                         | USA                          |
| Uganda [206]   | end-of-life               | No indication/no allocation        | Makerere University                                                  | Uganda                       |
| Uganda [207]   | Gate to gate              | No indication/no allocation        | Makerere University College of Agricultural & Environmental Sciences | Uganda                       |
| Zambia [208]   | Cradle-to-gate?           | No indication/no allocation        | Norwegian Geotechnical Institute (NGI)                               | Norway                       |
| Zambia [209]   | Cradle-to-gate?           | No indication/no allocation        | Norwegian Geotechnical Institute (NGI)                               | Norway                       |
| Zimbabwe [210] | Cradle to gate            | Mass allocation                    | University of Zimbabwe,                                              | Zimbabwe                     |
| Zimbabwe [211] | Cradle to gate            | No indication/no allocation        | University of Johannesburg                                          | South Africa                 |
| Zimbabwe [212] | Cradle to grave           | No indication/no allocation        | University Of Johannesburg                                          | South Africa                 |
| Zimbabwe [213] | Cradle to gate            | No indication/no allocation        | University Of Johannesburg                                          | South Africa                 |
| Zimbabwe [214] | Cradle to grave           | No indication/no allocation        | University of Zimbabwe                                               | Zimbabwe                     |
| Zimbabwe [215] | end-of-life               | No indication/no allocation        | University of Johannesburg                                          | South Africa                 |
| Zimbabwe [216] | end-of-life               | No indication/no allocation        | University of Johannesburg                                          | South Africa                 |
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