# Sustainability transitions in West African agriculture and food systems

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**Abstract—** Scientific evidence is crucial for the transition towards sustainable and resilient agri-food systems. However, sustainability transitions research has been so far north-biased and overlooked the Global South. This paper analyses the scholarly literature on sustainability transitions in West African agriculture and food systems. In particular, it investigates the bibliometrics and geographical coverage of the research field and explores whether and how it addresses topics such as transition frameworks, niches, food security and sustainability. The paper draws upon a systematic review of documents indexed in the Web of Science performed in July 2022. The low number of papers suggests that the research field is still marginal. The literature mainly deals with crop production whereas animal production and fisheries are generally overlooked. Only a few articles refer to a clear transition framework (e.g. Multi-Level Perspective). The addressed niches regard alternative agriculture systems (e.g. agroecology, agroforestry, climate-smart agriculture, conservation agriculture) and new agriculture techniques (e.g. irrigation). Food security and nutrition are still marginal topics in the research field. Sustainability transitions are argued to have positive environmental and socio-economic impacts. The promotion of research on sustainability transitions in West African agri-food systems is highly needed to address the multiple challenges that the region faces.

**Index Terms—** food security, food system transformation, multi-level perspective, niche, sustainability transitions, sustainability, sustainable agriculture, sustainable food systems.

## I. INTRODUCTION

In West Africa, agriculture has a high contribution to the gross domestic product (from 4.4% in Cabo Verde to 59.5% in Sierra Leone versus 4.3% worldwide) and employment (from 11% in Cabo Verde to 73% in Niger versus 27% globally). Meanwhile, food insecurity and malnutrition are big challenges in the region (Table 1). Indeed, the prevalence of undernourishment in the total population is still high in the region, averaging 12.5%; it ranged from 4.1% in Ghana to 38.3% in Liberia over the period 2019–21. The situation is even more alarming considering the prevalence of moderate or severe food insecurity that reached 57.0%

region-wide over the same period, ranging from 35.4% in Cabo Verde to 86.7% in Sierra Leone. Furthermore, evidence shows that the impacts of climate change will be high in Sub-Saharan Africa in general [1]–[4] and West Africa and the Sahel in particular [1], [4]. Agriculture, predominantly rain-fed, is highly vulnerable to climate variability. In this regard, Sultan and Gaetani [5] put that "*West Africa is known to be particularly vulnerable to climate change due to high climate variability, high reliance on rain-fed agriculture, and limited economic and institutional capacity to respond to climate variability and change*". These challenges show the urgent need to transition towards sustainable and resilient agri-food systems in the region.

There are different definitions of sustainability transitions i.e. transitions towards sustainability. According to Markard et al. [8], sustainability transitions refer to "*long-term, multi-dimensional and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption"* (p. 956). Meanwhile, Geels [9] posits that "*socio-technical transitions […] involve not just changes in technology but also changes in consumer practices, policies, cultural meanings, infrastructures, and business models*". Kern and Markard [10] highlight that sustainability transitions are long-term, complex, uncertain, multi-dimensional and context-dependent processes. Different frameworks have been used to study and comprehend the transition towards sustainability [8], [11]–[14]. Lachman [11] reviews the most prominent transition frameworks: the Multi-Level Perspective on socio-technical transitions (MLP), Transition Management (TM), Strategic Niche Management (SNM), Technological Innovation Systems (TIS), Techno-Economic Paradigm (TEP) shifts, and Socio-Metabolic Transitions. The socio-technical transitions approach includes a family of frameworks such as the Multi-Level Perspective [15], [16], Strategic Niche Management [17]–[19] and Transition Management [20]–[22].

Table 1. Agriculture and food security in West Africa.

| Country | Agriculture, forestry, and fishing, value added (% of GDP) (year) | Employment in agriculture (% of [illegible]) | Prevalence of undernourishment (% | Prevalence of moderate or severe food insecurity (% |
|---|---|---|---|---|
| Benin | 27.1 (2020) | 38 | 7.4 | 67.9 |
| Burkina Faso | 18.4 (2020) | 26 | 18.0 | 52.6 |
| Cabo Verde / Cape Verde | 4.4 (2021) | 11 | 17.7 | 35.4 |
| Côte d'Ivoire / Ivory Coast | 21.4 (2020) | 40 | 4.4 | 42.8 |
| The Gambia | 19.7 (2021) | 27 | 21.6 | 58.0 |
| Ghana | 19.7 (2021) | 30 | 4.1 | 36.6 |
| Guinea | 25.5 (2021) | 61 | n. a. | 73.3 |
| Guinea-Bissau | 30.9 (2020) | 60 | 31.7 | 75.0 |
| Liberia | 37.2 (2021) | 43 | 38.3 | 80.6 |
| Mali | 36.0 (2021) | 62 | 9.8 | n. a. |
| Mauritania | 20.2 (2020) | 31 | 10.1 | 45.3 |
| Niger | 36.4 (2021) | 73 | 19.8 | n. a. |

| | | | | |
|---|---|---|---|---|
| Nigeria | 23.4 (2021) | 35 | 12.7 | 58.5 |
| Senegal | 15.3 (2021) | 30 | 7.5 | 49.2 |
| Sierra Leone | 59.5 (2020) | 54 | 27.4 | 86.7 |
| Togo | 19.3 (2021) | 32 | 18.8 | 62.5 |
| *Source* | *World Bank* [6] | | *FAO et al.* [7] | |

GDP: Gross domestic product.

Since the publication of the first research agenda on sustainability transitions in July 2010 [23], the research field has deepened intellectually, broadened empirically and extended geographically. An increasing number of studies address sustainability transitions in the agriculture and food sectors [24]–[29]. However, sustainability transitions scholarship tended to overlook agri-food systems [8], [29]–[32]. The research field on agri-food sustainability transitions is rather young, still marginal in the mother field of sustainability transitions, and mainly performed in European universities and research centers [33]. This confirms the North-South gap [33]; sustainability transition studies are still largely carried out in developed countries of the Global North [11], [34]. Among the sub-sectors of agriculture (viz. crop production, fisheries/aquaculture and animal production), fisheries and animal production are underserved in the research field. Regarding the food chain stages, production (mainly crop production) is the most studied stage [33]. The considered niches include organic agriculture, agroecology, conservation agriculture, urban agriculture, permaculture, integrated agriculture/farming, care farming and alternative food networks (AFNs) [35]. The literature on sustainability transitions in agri-food systems is diverse and deals with all the themes of the research agenda of the Sustainability Transitions Research Network [36]. However, it focuses largely on 'governing and managing transitions', 'sustainable consumption' and 'power and politics in transitions', whereas the themes of 'modelling transitions', 'civil society, social movements and culture in transitions', and 'role of industries and firms in transitions' remain largely underserved [29]. In a systematic review, El Bilali [33] found that food and nutrition security is still a marginal topic in the research on agri-food sustainability transitions. In this context, the present paper analyses the scholarly literature on sustainability transitions in West African agriculture and food systems. In particular, it investigates the bibliometrics and geography of the research field and explores whether and how it addresses key topics such as transition frameworks, niches, food security pillars and sustainability dimensions.

## II. MATERIAL AND METHODS

The present systematic review follows the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [37], [38]. It draws upon a search performed on the Web of Science (WoS) on July 7th, 2022, using the following search string: *(sustainability OR sustainable) AND (transition OR transformation) AND (agriculture OR food) AND ("West* Africa" OR Sahel OR Benin OR Burkina OR "Cape Verde" OR "Cabo Verde" OR Gambia OR Ghana OR Guinea OR "Guinea-Bissau" OR "Ivory Coast" OR "Côte d'Ivoire" OR Liberia OR Mali OR Mauritania OR Niger OR Nigeria OR Senegal OR "Sierra Leone" OR Togo)*. The initial search on WoS returned 128 documents. The selection of the documents to be included in the systematic review was informed by the methodology

adopted by El Bilali [39], [40]. Table 2 describes the selection steps and process. Particularly, three inclusion/eligibility criteria were considered: geographical coverage (viz. the document deals with at least one West African country); thematic focus (viz. the document deals with transition/transformation in agri-food systems); and document type (viz. only articles, chapters or conference papers were selected; letters to editors, editorials, commentaries and/or notes were discarded). Only the documents that met all three criteria were included in the systematic review. For the purpose of the present paper, the terms 'transition' and 'transformation' are used interchangeably so that the article includes both papers dealing with transitions in agri-food systems as well as agri-food system transformation.

Following the screening of titles, 10 documents were excluded as they do not refer to West Africa; documents covering wider geographical areas (e.g. Sahel, Sub-Saharan Africa) or those where the geographical scope is not reported in the title were kept for further analysis. Additional 80 documents were excluded following the scrutiny of abstracts as they do not meet at least one of the eligibility criteria. For example, some documents refer to *Aspergillus niger*, a fungus, that has nothing to do with 'Niger' country. Moreover, 'Guinea' refers sometimes to Papua New Guinea instead of the two Western African countries (viz. Guinea and Guinea-Bissau). Documents that deal with land use/cover changes without any clear reference to the transition theory were discarded. Likewise, articles dealing with energy without referring to agriculture and food (e.g. biodiesels/biofuels) were excluded. Furthermore, 15 ineligible documents were discarded following the analysis of full-texts.

Table 2. Articles selection process.

| Selection steps | Number of selected documents | Number of documents excluded and exclusion reasons |
|---|---|---|
| Search on WoS | 128 | -- |
| Screening of documents based on titles | 128 | 10 documents excluded because they deal with countries outside West Africa e.g. Algeria, Chad, Fiji, Indonesia, Papua New Guinea, Rwanda and Tanzania |
| Screening of documents based on abstracts | 118 | 80 documents excluded:<br>• 4 documents that do not deal with West Africa/West African countries<br>• 5 documents that do not address agri-food systems<br>• 71 documents that do not deal with transition/transformation |
| Scrutiny of full-texts | 38 | 15 documents excluded since they do not address transition/transformation in agri-food systems |
| Inclusion in the systematic review | 23 | -- |

Consequently, only 23 documents resulted eligible and were included in the systematic review (Table 3); these include 21 journal articles and 2 proceeding papers.

Table 3. List of the selected documents.

| Year | Documents number | References |
|---|---|---|
| 2022* | 3 | Adeosun et al. [41]; Boillat et al. [42]; Karg et al. [43] |
| 2021 | 7 | Bottazzi and Boillat [44]; Jagustović et al. [45]; Kouassi et al. [46]; Morris et al. [47]; Sanon et al. [48]; Thondhlana et al. [49]; Zougmoré et al. [50] |
| 2020 | 3 | Borelli et al. [51]; Olawuyi and Mushunje [52]; Tapsoba et al. [53] |
| 2019 | 2 | Antwi-Bediako et al. [54]; Ruf et al. [55] |
| 2018 | 5 | Audouin et al. [56]; Havik et al. [57]; Ilieva and Hernandez [58]; Nygaard and Bolwig [59]; Osei-Amponsah et al. [60] |
| 2017 | 1 | Osunmuyiwa [61] |
| 2016 | 1 | Amjath-Babu et al. [62] |
| 2012 | 1 | Odeyale et al. [63] |

* As of July 7th, 2022.

The analysis of the selected documents regarded both the bibliometrics and topics addressed. Indeed, the analysis focused on bibliographical metrics, research geography, agriculture subsectors, food chain stages, transition frameworks, niches, food security pillars and sustainability dimensions (Table 4).

Table 4. Analyses undergone by the selected documents.

| Item | Description | Method reference |
|---|---|---|
| Bibliographical metrics | Sources/journals, research areas, authors, affiliation institutions/organizations and countries | El Bilali [39], [40] |
| Research geography | West African countries where studies were performed | El Bilali [39], [40] |
| Agriculture subsectors | Crop production (and main crops addressed), animal production/pastoralism and fisheries/aquaculture | El Bilali [39], [40] |
| Food chain stages | Production, processing, distribution/ retail/marketing, consumption and waste management | El Bilali [39], [40] |
| Transition frameworks | Multi-Level Perspective (MLP), Transition Management (TM), Strategic Niche Management (SNM), Technological Innovation Systems (TIS), Social Practice | El Bilali [64] |

| Item | Description | Method reference |
|---|---|---|
| | Approach (SPA), etc. | |
| Niches | Niches and novelties addressed | El Bilali [35] |
| Food security | Food security dimensions: availability, access, utilization/use and stability | El Bilali [33] |
| Sustainability | Sustainability dimensions: environment, economy, society, and policy and governance | El Bilali et al. [65] |

## III. Results and Discussion

### *A. Bibliometrics and research geography*

The analysis of the selected eligible documents suggests that research on sustainability transitions in agri-food systems is rather young in West Africa; the first document indexed in WoS [63] dates back to 2012. The *annual output* of articles is rather low but the peak of the number of publications in 2021 (7 articles) might suggest that interest in the research field is increasing across the region.

Concerning *sources*, the analysis of the results shows that the maximum number of articles was published in *Sustainability* (8 articles), which is so far the most important publication outlet. However, the findings of the research on sustainability transitions in West African agri-food systems were published in 17 further sources and journals. Most of the selected articles fall under the *research areas* of *environmental sciences - ecology* (12 out of 23 articles, 52.2%), *science technology* (11 articles, 47.8%), *agriculture* (8 articles, 34.8%) and *plant sciences* (2, 8.7%). Nevertheless, the selected 23 publications can be categorized in 11 research areas (e.g. food science technology, geography, sociology), which shows that the research field is multidisciplinary.

The bibliometric analysis shows that the most prominent, productive *authors* are Sebastien Boillat, Patrick Bottazzi and Robert Zougmoré (2 articles each). Nevertheless, the fact that 106 scholars co-authored the 23 eligible articles shows, on the one side, that there is an extended collaboration in the research field but, on the other side, might suggest a lack of consistency and specialization in the research field i.e. even authors dealing with this research field sporadically do that. This, in turn, might be due to the absence of structured research projects/programs because of the lack of investments in research on sustainability transitions in general and agri-food sustainability transitions in particular in West Africa.

The analysis of *countries* and *affiliations* suggests that the most active country in the research field is the Netherlands (7 articles, 30.4%) followed by France and Burkina Faso (4 articles each). The 23 eligible articles were authored by scholars from 29 countries. Apart from Burkina Faso, affiliation West African countries also include Mali (3 articles), Cote d'Ivoire, Ghana and Nigeria (2 articles each), and Benin (1 article). Nevertheless, a large share of the selected documents is authored by researchers based outside West Africa; either in Africa (e.g. Ethiopia, Kenya, Madagascar, South Africa), Asia (e.g. Bangladesh, Sri Lanka), Europe (e.g. Austria, Belgium, Denmark, England, Germany, Italy, Netherlands, Portugal, Switzerland), Latin America (e.g. Brazil, Colombia) or Oceania (e.g. Australia). In this context, it comes as no surprise that the most important funding agencies are based outside West Africa, especially in Europe (e.g. European Commission, Austrian Development Cooperation) or international organizations

(Consultative Group on International Agricultural Research - CGIAR).

Furthermore, the 23 selected articles were authored by researchers from 68 *institutions*. Many of the prominent institutions in the research field are based outside West Africa. These institutions include the CGIAR, Wageningen University & Research (Netherlands), Alliance of Bioversity International – CIAT (*Centro Internacional de Agricultura Tropical*), CIRAD (*Centre de coopération internationale en recherche agronomique pour le développement*, France), University of Montpellier (France), University of Bern (Switzerland), and CIHEAM (International Centre for Advanced Mediterranean Agronomic Studies). However, many organizations based in West Africa are active in the research field such as the Polytechnic University Nazi Boni (Burkina Faso), CNRST (National Center for Scientific and Technical Research, Burkina Faso) and the Federal University of Technology in Akure (Nigeria).

The analysis of the *geography of research* in the region suggests that there are considerable differences among West African countries (Table 5). Indeed, research on sustainability transitions in agri-food systems was mainly performed in Nigeria (4 studies), Ghana (3 studies), and Burkina Faso and Ivory Coast (2 studies each). Meanwhile, no article deals specifically with sustainability transitions in agri-food systems in many West African countries viz. Benin, Cabo Verde, Gambia, Guinea, Liberia, Mauritania, Niger, Sierra Leone and Togo. This suggests a huge gap in this research field in the concerned countries. Furthermore, there is no single study that addresses sustainability transitions in agri-food systems in the whole of West Africa but there are some multi-country studies. For instance, Karg et al. [43] analyze food flows and the roles of cities in food distribution networks in Ouagadougou (Burkina Faso), Bamako (Mali), Tamale (Ghana) and Bamenda (Cameroon). Likewise, Thondhlana et al. [49] provide a reflective account of lessons learned from the facilitation of urban sustainability through transdisciplinary research in Ghana, South Africa and Zimbabwe. Zougmoré et al. [50] explore the role of climate-smart agriculture in the transformation of food systems in Western Africa (viz. Ghana, Senegal, Mali and Burkina Faso) and Eastern Africa (viz. Ethiopia, Kenya, Rwanda and Tanzania) under climate change pressure. Other studies are rather global; for instance, Borelli et al. [51] investigate the contribution of orphan crops and wild edible species to the transformation of food Systems in Brazil, Kenya, Guatemala, India, Mali, Sri Lanka and Turkey.

Table 5. Geography of research on agri-food sustainability transitions in West Africa.

| West African country (articles number) | Document |
|---|---|
| Burkina Faso (2) | Audouin et al. [56]; Sanon et al. [48] |
| Ivory Coast (2) | Kouassi et al. [46]; Ruf et al. [55] |
| Ghana (3) | Jagustović et al. [45]; Nygaard and Bolwig [59]; Osei-Amponsah et al. [60] |
| Guinea-Bissau (1) | Havik et al. [57] |
| Nigeria (4) | Adeosun et al. [41]; Odeyale et al. [63]; Olawuyi and Mushunje [52]; Osunmuyiwa [61] |
| Senegal (2) | Boillat et al. [42]; Bottazzi and Boillat [44] |
| West Africa* (1) | Tapsoba et al. [53] |
| Sub-Saharan Africa** (5) | Amjath-Babu et al. [62]; Karg et al. [43]; Morris et al. [47]; Thondhlana et al. [49]; Zougmoré et al. [50] |
| Global*** (3) | Antwi-Bediako et al. [54]; Borelli et al. [51]; Ilieva and Hernandez [58] |

* This group includes documents addressing at least two countries from West Africa.

** This group includes documents addressing at least another Sub-African country outside West Africa.

*** This group includes documents addressing at least a country outside Sub-African Africa.

*B. Agriculture subsectors and food chain stages*

Concerning the *agriculture subsectors*, the analysis of the selected documents suggests that the literature on sustainability transitions in West African agri-food systems mainly deals with crop production whereas animal production/pastoralism and fisheries/aquaculture are generally overlooked. Indeed, only a few articles deal with animal production/livestock [47] and fisheries [48]. As for crop production, the majority of the papers focus on staple crops or cash, export ones. Indeed, several articles deals with cocoa [46], cassava [60], cashew [55], [56] and soybean [60]. Interestingly, some articles also deal with the role of neglected and underutilized crop species in food system transformation [51] as well as the introduction of exotic cultivated species [57]. Only a few articles deal with integrated agriculture systems. For instance, Morris et al. [47] investigate the multi-stakeholder social learning processes within mixed crop-livestock communities in several African countries (viz. Burkina Faso, Ethiopia and Tanzania). Nevertheless, many articles deal with the transformation of consumption patterns and distribution networks without any distinction between agriculture subsectors or focusing on specific crops [41], [43]. Other articles go a step further and analyze transition processes beyond the agricultural sector or at the interface between agriculture and other sectors (e.g. energy). This is particularly the case of studies dealing with the development, successes but also failures, of biofuels in general [61] or specific examples of biofuel plants such as jatropha [54], [59].

As for the *food chain stages*, most of the selected documents deal with either the upstream (cf. production) or downstream (cf. marketing/consumption) of the food chain; intermediate stages (e.g. processing, packing) are often overlooked. As for production, the selected articles focus, inter alia, on different alternative agriculture production systems and models such as agroforestry [46], agroecology [42], [44], [53], climate-smart agriculture [45], [50] and conservation

agriculture [52]. Meanwhile, some studies focus on transition in specific agricultural techniques and practices such as irrigation [62]. Articles addressing the downstream of the food chain focus, among others, on shifts in patterns of daily food consumption [41] and changing distribution networks/markets [43], [63]. Some articles take a more holistic, systemic approach and analyze the processes of transformation within different stages of the food system [51], [58]. Other studies, especially those inspired by or falling within the field of geography, emphasize the territorial dimension and analyze the historical transformation processes and changes across sectors in specific territories and areas [57].

*C. Transition frameworks*

The results of the systematic review show that only a few articles (6 articles out of the 23 selected ones) refer to a clear transition framework. These are the Multi-Level Perspective (MLP), Social Practice Approach (SPA) and Innovation systems. As expected, the quantitative analysis of the results shows that the MLP is the most prominent framework [42], [48], [59] followed by innovations systems [56], [58] and SPA (cf. practice-based approach) [41], [42]. Meanwhile, no study refers to Transition Management (TM) and Strategic Niche Management (SNM). Furthermore, the analysis suggests that only a few of the selected articles integrate different transition frameworks. For example, Boillat et al. [42] combine MLP and Bourdieu's theory of practices (cf. SPA) to analyze the agroecological transition in Senegal. However, some studies integrate transition frameworks with other methods, such as the social network analysis [42], to better grasp and comprehend the transition dynamics and processes. Others rely completely on alternative methods, such as institutional logics theory [60] and actor network theory [63], without any reference to the transition frameworks.

The analysis of the literature also shows that there is a correspondence between the used transition framework and the food chain stage that is addressed. For instance, the SPA is mainly used to analyze transition in consumption patterns and practices [41] whereas the MLP is generally utilized to investigate shifts in production practices and systems as well as the adoption of new technologies in agriculture [42], [48], [59]. For instance, Adeosun et al. [41] use a practice-based approach to analyze the interrelations and interactions between daily lives and out-of-home food consumption practices among the urban poor in Ibadan city, Nigeria. Sanon et al. [48] use the MLP to investigate the dynamics of transition in inland fisheries and the development of the fish farming niche in Burkina Faso. Meanwhile, the innovation system approach [56] is more concerned with the diffusion of innovation as well as the functioning and governance of the territorial innovation ecosystem. For instance, Audouin et al. [56] use the example of the cashew trees in Burkina Faso to conceptualize and analyze how place-specificities and spatial/territorial relationships affect the dynamics and functioning of the technological innovation systems (TIS).

*D. Niches*

The results of the analysis of the niches addressed in the selected documents are in line with those obtained at the global level [35] The addressed niches mainly regard alternative agriculture systems and new agriculture techniques that are considered to contribute to the transition toward more sustainable agriculture and food systems. Indeed, the selected articles deal with different alternative agriculture production

models such as agroecology [42], [44], [53], agroforestry [46], climate-smart agriculture [45], [50], conservation agriculture [52] and fish farming/aquaculture [48]. Boillat et al. [42] conceptualize the agroecological network in Senegal as a niche, with its protective space, shaped by the flows of resources, knowledge and capitals and analyze the role of transnational links on the empowerment potential of the agroecological niche. Kouassi et al. [46] analyze the barriers to the adoption of agroforestry by cocoa farmers in the southwestern Ivory Coast. Jagustović et al. [45] identify short- and long-term trade-offs and synergies in climate-smart agriculture to inform the sustainable transformation processes of agri-food systems in northern Ghana. Meanwhile, Zougmoré et al. [50] investigate the role of climate-smart agriculture in the transformation of agri-food systems in Sub-Saharan Africa (viz. Burkina Faso, Ethiopia, Ghana, Kenya, Mali, Rwanda, Senegal, Tanzania) under the pressure of climate change and variability. Olawuyi and Mushunje [52] shed light on the relationships between the acquisition of information by smallholder farmers in Southwestern Nigeria and the adoption of conservation agriculture. Sanon et al. [48] analyze the dynamics of transition in inland fisheries and the development of the aquaculture niche in Burkina Faso and explore its implications for the sustainable management of natural resources (cf. water resources), food security and livelihoods.

Niches can also relate to some components of the agricultural system such as crops. These include studies analyzing the development of crops such as biofuel ones [54], [59] and cashew [56]. For instance, Nygaard and Bolwig [59] cast light on the development of the jatropha biofuel value chain in Ghana and relate it to the rise and fall of foreign private investment in the biofuel sector. In the meantime, some studies focus on the adoption of new agricultural techniques and practices such as irrigation [62], which, anyway, imply a transition from rainfed to irrigated agriculture. For example, Amjath-Babu et al. [62] analyze the dynamics of transitioning from rainfed agriculture to groundwater-irrigated intensive agriculture in Sub-Saharan Africa (viz. Burkina Faso, Cameroon, Ethiopia, Ghana, Malawi, Namibia, Nigeria, Zambia, Zimbabwe).

*E. Food security*

The literature review suggests that only a few studies on sustainability transitions in West African agri-food systems deal with food security and nutrition. This result is in line with the finding of the systematic review on food security and nutrition in studies on agri-food sustainability transitions carried out by El Bilali [33]. Indeed, he found that food security and nutrition are still marginal topics in the research field. However, this result is rather surprising considering the specific context of West Africa. Indeed, whereas most studies on agri-food sustainability transitions are carried out in the Global North [33], where food insecurity and malnutrition are not relevant challenges, the prevalence of undernourishment and food insecurity is still high in West Africa [66]. Therefore, one would expect paying more attention to these central topics in the studies on agri-food sustainability transitions in the region.

In general, many studies refer to food (in)security to justify and ground the need for agri-food sustainability transitions [46], [48]–[50], [53], [57], [60], [62]. However, only a few of them refer to food security when addressing the impacts and implications of sustainability transition processes.

As for the food security dimensions and pillars (viz. availability, access, utilization and stability), most of the selected articles

that deal with food security address food production and supply, and consequently food availability [45], [48], [51], [57], [60], [62], whereas the other three dimensions are generally overlooked. As for food access, Karg et al. [43] investigate the roles of cities in food distribution networks and food flows across Western Africa (Ouagadougou, Burkina Faso; Bamako, Mali; Tamale, Ghana) and Central Africa (Bamenda, Cameroon). Regarding food use, Adeosun et al. [41] analyze the interaction between the urban daily lives of the urban poor and shifts in the out-of-home food consumption patterns in Nigeria. Other studies suggest that sustainability transitions contribute to improved nutrition and dietary diversity [48], [51]. Concerning the stability dimension, studies that deal with mitigation of and adaptation to climate change also refer to agriculture and food system resilience. This is mainly the case of studies that analyze the effects of the adoption and upscaling of climate-smart agriculture [45], [50].

Some studies show that agri-food sustainability transitions can affect simultaneously different dimensions of food security. For instance, Jagustović et al. [45] suggest that the transition to climate-smart agriculture can increase productivity (cf. food availability), income (cf. food access), and agriculture resilience (cf. stability dimension) in northern Ghana. Meanwhile, Sanon et al. [48] argue that the development of fish farming in Burkina Faso will contribute to increasing fish availability and accessibility in remote areas (cf. food availability/access), improving the income and livelihoods of rural communities (cf. food access) and increasing dietary diversity by fostering fish consumption (cf. food use). Borelli et al. [51] suggest that the increased cultivation and/or use of orphan crops and wild edible species can improve food availability, affordability (cf. food access), nutrition and dietary diversity (cf. food use), and agricultural systems climate-resilience (cf. stability).

*F. Sustainability dimensions*

Many articles refer to the current challenges and problems in West Africa to substantiate and corroborate the need for the transformation of agri-food systems in the region. These challenges fall under the environmental, social and economic dimensions of sustainability. Environmental challenges include climate change [45], [46], [48]–[50], [54], [55], [60], [62], resources depletion and degradation [46], [48], [52], [53], biodiversity loss [46], [51], [57], pollution [49] and waste generation [63]. Socio-economic challenges relate to food insecurity and malnutrition [46], [48]–[50], [53], [57], [60], [62], poverty and livelihoods vulnerability [46], [48], population growth [45], [53], [62], rapid urbanization [41], [43], [49], [63], land tenure insecurity [55], [59], and health issues relating, among others, to non-communicable diseases (NCD) and food safety [51].

Meanwhile, also the analyses of sustainability transition processes and outcomes are often carried out through one of the sustainability dimensions. For instance, some articles focus on resource efficiency and productivity gains [48], [50]. Indeed, sustainability transitions, especially through the adoption of alternative agriculture systems, are argued to increase the productivity and efficiency of the use of different resources such as water [50], land [52] and reduce waste [50], [63]. They are also assumed to contribute to climate change mitigation and/or adaptation [50], [51], [55], [58] and biodiversity conservation [51]. Other studies mainly deal with the socio-economic implications and impacts of sustainability transitions [44], [47], [48], [50], [54], [58]. The positive socio-economic impacts of

agri-food sustainability in West Africa regard food security and nutrition [47], [48], [51], income and livelihoods [47], [48], [50], empowerment [42], [48], [60], and knowledge sharing and learning [52], [58]. Investment is a central element in sustainability transition endeavors as shown by the example of biofuels [54], [59]. Other studies are mainly concerned with the politics and governance of transition processes [42], [44], [48], [53], [56], [60], [61]. In general, these studies show that sustainability transition processes and dynamics are shaped by the political and institutional contexts in which they take place [56], [60]. These also include studies addressing power relations and imbalances in food supply chains [59].

However, as in the case of food security, some analyses address at the same time the different dimensions of sustainability. For instance, Sanon et al. [48] investigate the implications of the ongoing transition in inland fisheries in Burkina Faso in terms of sustainable management of natural resources (cf. environmental dimension), food security and livelihoods (cf. socio-economic dimension) and explore how transition processes are shaped by policy trends and developments (cf. policy and governance dimension). Jagustović et al. [45] suggest that the transition to climate-smart agriculture can improve climate resilience (cf. environmental dimensions), food security and nutrition (social dimension) and income (cf. economic dimension). Borelli et al. [51] posit that the increased cultivation and use of orphan crops can improve food security, nutrition and livelihoods (socio-economic dimension) and climate resilience (cf. environmental dimension).

Apart from the multi-dimensional impacts and outcomes of sustainability transition processes, some scholars combine the different dimensions even in their analyses [42], [44], [53]. For instance, Boillat et al. [42] analyse the effects of transnational links/partnerships and uneven empowerment (cf. policy/governance) on agroecological transition (cf. environment) in Senegal. Meanwhile, Bottazzi and Boillat [44] address 'Political Agroecology' in Senegal. Tapsoba et al. [53] shed light on the political, institutional, organizational, and social levers and barriers for an agroecological transition in Burkina Faso and Benin.

Some studies address sustainability alongside resilience. They suggest that sustainability transition processes not only improve the sustainability of agriculture and food systems but also their resilience [58]. For instance, Ilieva and Hernandez [58] argue that grassroots, social and bottom-up innovations have enabled local communities to drive system-wide transformations toward climate adaptation, sustainability and resilience in the agri-food systems in different socioeconomic and geographic contexts (cf. Brazil, New York - USA, and Senegal).

Studies also suggest that transitions in agri-food systems are far from being a panacea and they can create synergies as well as trade-offs among the sustainability dimensions. For instance, the development of biofuels [54], [59], [61] can help mitigate climate change (cf. environmental dimension) but can also have negative implications in terms of food security (social dimension) and, even, land degradation (environmental dimension). Meanwhile, referring to climate-smart agriculture in Northern Ghana, Jagustović et al. [45] put that "*results reveal short-term progress towards the goal of increased productivity and income, with trade-offs in the goals of GHG removal, climate adaptation, and resilience*". Referring to sustainable livestock transformation in Sub-Saharan Africa (viz. Burkina Faso, Ethiopia and Tanzania), Morris

et al. [47] found that there are numerous trade-offs such as between household food and animal feed, and between livestock for labor, income and/or cultural functions. Meanwhile, the transition to irrigated agriculture [62] can improve livelihoods and food security (social dimension) but may lead to the depletion of underground water (environmental dimension).

## IV. CONCLUSIONS

To the best of our knowledge, this is the first Web of Science-based systematic review that analyses comprehensively the scholarly literature on agri-food sustainability transitions in West Africa. The analysis shows an increasing interest in the nascent research field, but the low number of papers and annual output suggest that it is still marginal in the domestic research system. This is confirmed also by the large share of articles authored by scholars and researchers affiliated with institutions based outside West Africa. Furthermore, the most important funding agencies are also based outside the region. However, the situation within the region is far from being homogeneous; research on sustainability transitions in agri-food systems was mainly performed in Nigeria, Ghana, Burkina Faso and Ivory Coast, whereas the other West African countries lag behind.

The literature on sustainability transitions in West African agri-food systems mainly deals with crop production whereas animal production/pastoralism and fisheries/aquaculture are generally overlooked. Some articles analyze transition processes beyond the agricultural sector or at the interface between agriculture and other sectors (e.g. energy). Meanwhile, most of the selected documents deal with either the upstream (cf. production) or downstream (cf. marketing/consumption) of the food chain; intermediate stages (e.g. processing, packing) are often overlooked. However, some articles take a more holistic, systemic approach and analyze transformation processes within different stages of the food system. Only a few articles refer to a clear transition framework. These are MLP, SPA and innovation systems. There is a correspondence between the used transition framework and the food chain stage that is addressed; SPA is mainly used to analyze transition in consumption patterns and practices whereas the MLP is generally utilized to investigate shifts in production practices and systems. The addressed niches mainly regard alternative agriculture systems and new agriculture techniques. Indeed, the selected articles deal with different alternative agriculture production models such as agroecology, agroforestry, climate-smart agriculture, conservation agriculture and fish farming/aquaculture. Niches also relate to some components of the agricultural system such as new crops or agricultural techniques and practices (e.g. irrigation). Only a few studies on sustainability transitions in West African agri-food systems deal with food security and nutrition. This result is rather surprising as food insecurity and malnutrition are still relevant challenges in West Africa. Most of the selected articles that deal with food security address food production and supply, and consequently food availability, whereas the other three dimensions (viz. access, utilization and stability) are generally overlooked.

Many articles refer to the current challenges and problems in West Africa to substantiate and corroborate the need for the transformation of agri-food systems in the region. These challenges fall under the environmental (e.g. climate change, resources depletion and degradation, biodiversity loss,

pollution), socio-economic (e.g. food insecurity and malnutrition, poverty, livelihoods vulnerability, urbanization, health) dimensions of sustainability. Meanwhile, sustainability transitions are argued to increase resource use efficiency and productivity, and contribute to climate change mitigation and/or adaptation and biodiversity conservation. The positive socio-economic impacts of agri-food sustainability in West Africa regard food security and nutrition, income and livelihoods, and the empowerment of stakeholders. Some studies argue that sustainability transition processes not only improve the sustainability of agriculture and food systems but also their resilience. Studies also suggest that sustainability transitions in agri-food systems are far from being a panacea and they can create synergies as well as trade-offs among the sustainability dimensions.

The promotion of research on sustainability transitions in West African agri-food systems is highly needed to address the multiple environmental, social and economic challenges that the region faces and where agri-food systems play a central role. This will allow not only to understand the dynamics and processes of transitions as well as their sustainability impacts and outcomes but also to design evidence-based interventions to bring about the needed transformation to make the regional agriculture and food systems more resilient and sustainable.

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