Landscape and Urban Planning 215 (2021) 104186

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

As the city grows, what do farmers do? A systematic review of urban and peri-urban agriculture under rapid urban growth across the Global South

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HIGHLIGHTS

- Comprehensive overview of UPA dynamics under rapid urban growth across the Global South.
- Reconceptualization of urban growth-related, spatiotemporal dynamics of UPA.
- Agricultural land conversion and peripheralization of UPA are widespread.
- Abandonment of UPA often also linked to non-availability of water and labour.
- Results call for multi-dimensional, longitudinal, and comparative research on UPA.

ARTICLE INFO

Keywords:
Urban and peri-urban agriculture
Urban growth
Spatiotemporal dynamics
Global South
Meta-analysis
Systematic review

ABSTRACT

Rapid urban growth poses increasing challenges, but also opportunities, for urban and peri-urban agriculture (UPA). This systematic review explores the nexus between UPA and urban growth through a meta-analysis of research on UPA in Africa, Asia, and Latin America. We reviewed 92 empirical articles, reporting on 83 cities, by applying a framework focused on interactions between urban growth, agricultural production factors, and urban food markets. Results show that the most reported challenges facing UPA are agricultural land conversion and peripheralization. Yet, a number of studies indicate spatial expansion and intensification of UPA due to increasing and changing food demand. Urban growth-related dynamics in the availability of water, organic fertilizer, and labour can further foster or constrain UPA. Consequently, farmers respond and adapt to urban growth in multiple ways. These findings indicate a complex, multi-dimensional challenge for planners and policy makers seeking to manage UPA in rapidly urbanizing landscapes. Yet, our meta-analysis shows that few studies holistically address spatiotemporal dynamics, intra-urban variations, and complex multi-dimensional interlinkages of UPA under urban growth. To overcome these limitations and chart a new framework for future research, we reconceptualize the spatiotemporal dynamics of UPA under urban growth as a *wheel of urban growth-related UPA dynamics*. To apply this framework, we call for further mixed-methods research linking multi-temporal, remotely sensed data to longitudinal qualitative and quantitative fieldwork data, in order to better understand and critically assess the multifaceted and dynamic socio-spatial changes of UPA in cities across the Global South.

1. Introduction

Rapid urban growth, and the simultaneous conversion of fertile agricultural land into built-up urban areas, are emerging as key challenges for urban food security and sustainability (Abass, Adanu, & Agyemang, 2018; Pandey & Seto, 2015; Zoomers, van Noorloos, Otsuki, Steel, & van Westen, 2017). By 2050, about two-thirds of the world's population will live in cities, and most future urban growth (about 90%) will occur in the Global South (UN, 2018). The interlinked challenges of urban food security and sustainability are highlighted in the Sustainable Development Goals, "Zero Hunger" (SDG 2) and "Sustainable Cities and Communities" (SDG 11). In this context, urban and peri-urban agriculture (UPA) plays a multi-functional role (Zasada, 2011) as a food supplier, livelihood strategy, and employment opportunity (Lerner & Eakin,

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https://doi.org/10.1016/j.landurbplan.2021.104186
Received 4 February 2021; Received in revised form 31 May 2021; Accepted 27 June 2021
Available online 27 July 2021
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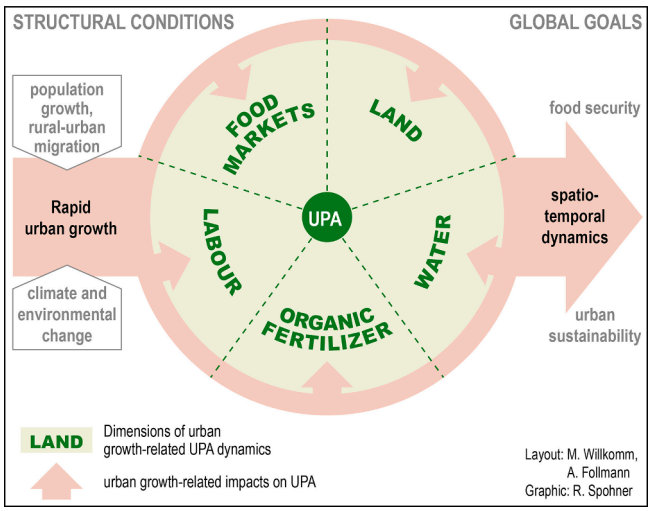

Fig. 1. Urban growth-related UPA dimensions.

2011; Zezza & Tasciotti, 2010), as well as contributing to urban sustainability through ecosystem services and by closing resource cycles (De Bon, Parrot, & Moustier, 2010; Lee, Ahern, & Yeh, 2015). To achieve SDGs, UPA is often promoted in urban landscape planning and policy (Coles & Costa, 2018; Nicholls, Ely, Birkin, Basu, & Goulson, 2020).

The growth of cities across the Global South, however, leads to increasing pressure on local *agricultural production factors*, such as land, water, (organic) fertilizer, and labour (Thebo, Drechsel, & Lambin, 2014; Zoomers et al., 2017). Simultaneously, growing urban populations, rising income levels (at least in some countries and cities), emerging urban middle classes, changing diets (Satterthwaite, McGranahan, & Tacoli, 2010), and persistent constraints for long-distance food distribution, all provide increasing market opportunities for UPA (Moustier & Renting, 2015; Orsini, Kahane, Nono-Womdim, & Gianquinto, 2013). Therefore, the relation between UPA and urban growth emerges as complex and multi-layered. Empirical findings often remain context-specific and sometimes seem contradictory. For example, some studies indicate a decline in UPA (Cobbinah, Gaisie, & Owusu-Amponsah, 2015; Kuusaana & Eledi, 2015), while others suggest the increasing importance of UPA in Global South cities (Drechsel & Dongus, 2010; Lerner & Eakin, 2011). A number of studies focus *a priori* on the replacement of UPA, for example, by asking: "As the city grows, where do the farmers go?" (Kuusaana & Eledi, 2015), thereby potentially overlooking other UPA dynamics. In this context, Thebo et al. (2014, p.8) observe that the "[g]rowing uncertainty in water resources availability, rapidly expanding urban populations, increasing urban food demand, and the rising incidence of rural–urban interactions along the peri-urban interface all underpin the need for a deeper understanding of the extent and drivers of urban and peri-urban agriculture across multiple scales." By following this multi-dimensional approach, therefore, the central question is: *As the city grows, what do farmers do*?

In this systematic review, we focus on the relation between UPA and urban growth in the *Global South* as 1) current and future urban growth is mainly a phenomenon of this part of the globe (UN 2018), and 2) UPA plays a greater role for urban livelihoods and food security compared to cities of the Global North (Hamilton et al., 2014; Orsini et al., 2013).

1.1. Conceptualizing dimensions of UPA under rapid urban growth

UPA is a heterogeneous, highly context specific phenomenon, as farming practices, motivations, spatial characteristics, as well as socio-economic and ecological impacts of UPA greatly vary across the Global South (De Bon et al., 2010; Lerner & Eakin, 2011; Moustier & Danso, 2006). Spatially, UPA is found on both private and public land. UPA is often an informal activity and farmers operate without legal protection or even against existing laws and regulations (Orsini et al., 2013). Due to spatial restrictions (e.g., small plots), and proximity to the market, perishable and high-value products (including vegetables, milk, and eggs) are most common (De Zeeuw, Van Veenhuizen, & Dubbeling, 2011; Mougeot, 2000).

Given the heterogeneity of UPA, definitions of UPA also vary. Most studies agree that UPA differs from rural agriculture insofar as it is geographically and institutionally deeply embedded within urban socio-economic and ecological systems, including highly competitive urban land markets and competition over resources (e.g. Mougeot, 2000). In terms of distance from city centres, however, a clear spatial demarcation between UPA and rural agriculture is conceptually controversial and empirically difficult – if not impossible (see e.g. Karg et al., 2019; Schlesinger, 2013). Therefore, we use a broad definition of UPA to include all kinds of agricultural activity taking place "in and around cities" (Schlesinger, 2013, p.31).

In the context of rapid urban growth, UPA has received increasing attention among researchers and policy-makers, as key to sustainable urban development and urban food security (Abu Hatab, Cavinato, Lindemer, & Lagerkvist, 2019; Nicholls et al., 2020). By using urban and peri-urban land for agricultural production and being deeply embedded in local resource flows of water, organic wastes, and labour, UPA is an integral part of urban landscapes and urban food systems (Zezza & Tasciotti, 2010).

Against this background, this review focuses on factors that contribute to the decline (abandonment or replacement), persistence or even increase (intensification or spatial expansion) of UPA activities in cities of the Global South. In doing so, we concentrate our analysis on *urban-growth related changes* affecting farmers' use of local agricultural production factors land, water, organic fertilizer and labour. While urban growth may also affect other agricultural production factors, such as financial capital (Cabannes, 2012) or inorganic fertilizer use (Jiang & Li, 2016), we focus on the *local* production factors as they are directly influenced by localized patterns of urban growth and are widely discussed in the literature on UPA's contribution to sustainable urban development (De Bon et al., 2010; De Zeeuw et al., 2011; Orsini et al., 2013):

- Fertile **land** is an important, immovable resource for farmers. Simultaneously, land conversion from agricultural to urban uses is pervasive across the Global South (Pandey & Seto, 2015; Satterthwaite et al., 2010; Zoomers et al., 2017);
- Urban growth often results in increasing **water** demand and water pollution problems (Dos Santos et al., 2017; Flörke, Schneider, & McDonald, 2018), putting pressure on UPA;
- The use of **organic waste as fertilizer** is common in UPA (Drechsel, Keraita, Cofie, & Nikiema, 2015). However, urban growth-related changes in urban waste production, such as increasing shares of inorganic waste or centralized waste management (Millington & Lawhon, 2019), affect UPA's access to organic waste as fertilizer (Hofmann, 2013; Nunan, 2000);
- Urbanization is generally associated with increasing opportunity costs of UPA and improved off-farm labour opportunities (Lerner & Eakin, 2011; Steinhübel & von Cramon-Taubadel, 2021), which is expected to affect **labour** relations in UPA.

Besides local agricultural production factors, we further pay attention to urban and peri-urban farmers' participation in changing food markets to include urban growth-related transformations in both input and output relations of UPA:

- **Urban food market** dynamics, including increasing and changing demands for perishable, high-value agricultural products (Satterthwaite et al., 2010), as well as changes on the supply side, such as supermarketization (Humphrey, 2007), are expected to affect UPA in numerous ways (Lerner & Eakin, 2011; Moustier & Renting, 2015).

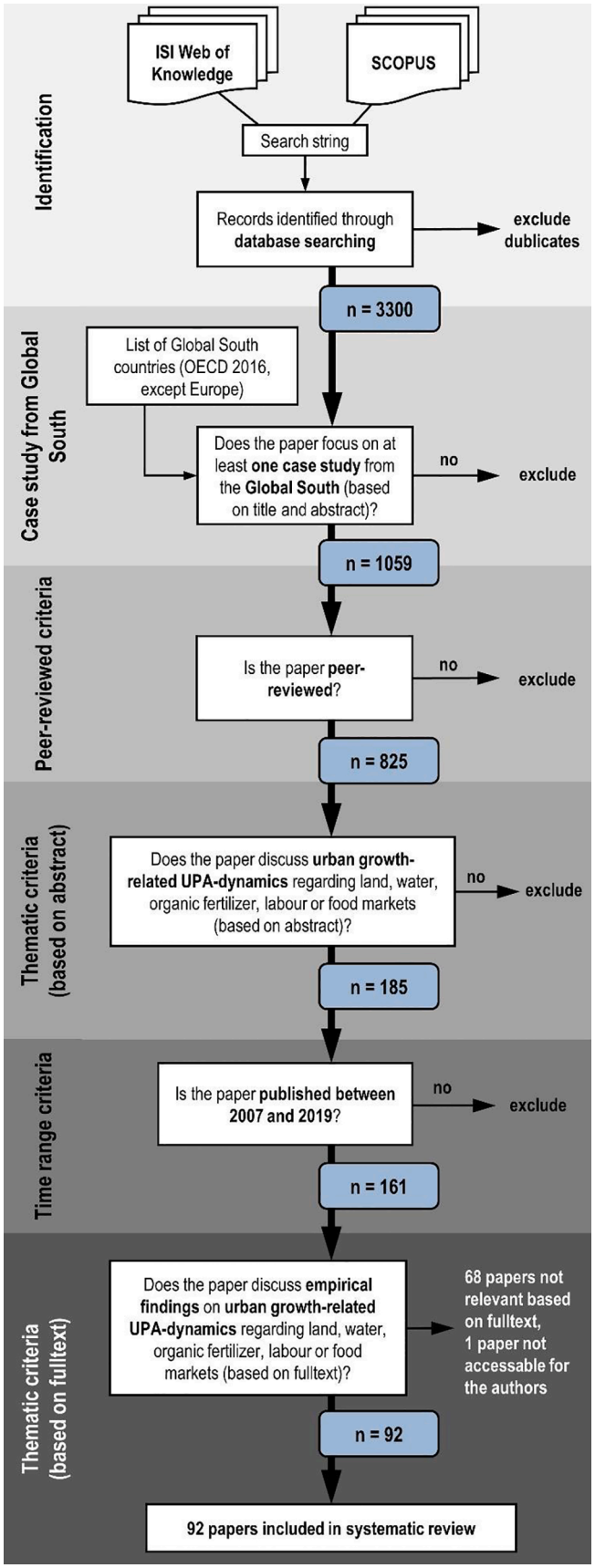

Fig. 2. Selection process.

In sum, we focus on urban-growth related dynamics in 1) land, 2) water, 3) organic fertilizer, 4) labour, and 5) food markets (see Fig. 1) and how these affect UPA. In other words, we analyse *what the farmers (must or can) do in the context of urban growth-related changes* along these five dimensions. As outlined above, the five analytical dimensions are derived from the existing literature and are, therefore, set *a priori* of the metanalysis. They are (1) embedded in structural conditions of rapid population growth, rural-to-urban migration, and climate and environmental change; and (2) factors determining UPA's contribution to global food security and urban sustainability goals (see Fig. 1).

1.2. *Knowledge gaps to be addressed*

While a growing number of case studies document complex and contradictory urban-growth dynamics of UPA across the Global South, there have been no systematic literature reviews that synthesize evidence from a wide range of international case studies. Existing reviews highlight UPA's relation to urban sustainability and resilience (De Bon et al., 2010; De Zeeuw et al., 2011; Orsini et al., 2013), climate and environmental change (Lwasa et al., 2015), food and nutrition security (Poulsen, McNab, Clayton, & Neff, 2015; Warren, Hawkesworth, & Knai, 2015), poverty alleviation (Hamilton et al., 2014), as well as connections between poverty alleviation and climate change (Lwasa et al., 2014). A number of reviews are narrative-based (cf. De Bon et al., 2010; De Zeeuw et al., 2011; Hamilton et al., 2014; Orsini et al., 2013), without a systematic selection of reviewed literature.

Most importantly, urban growth is rarely at the centre of such analyses, and is instead a vaguely defined structural condition underlying UPA transformations. Moreover, existing reviews focus on rapid urbanization, food security, and agricultural transformations (Abu Hatab et al., 2019), while only marginally addressing UPA as one aspect of larger urban–rural food systems. Finally, none of the existing reviews explicitly engage with questions of how urban and peri-urban farmers react and adapt farming practices to rapid urban growth. Farmers are instead typically presented as passive and helpless in the face of rapid urban growth; as Yang, Hao, Liu, and Cai (2016, p.222) note, "the active responses of the agricultural sector are rarely examined". Therefore, the relation between urban growth and UPA dynamics is unclear. Additionally, none of the existing reviews relate empirical findings to methods used in UPA research.

Against this backdrop, and seeking to advance understanding of the complexity of urban growth-related UPA dynamics across the Global South, this systematic review develops a dynamic and multi-dimensional framework on urban-growth-related UPA transformations and multifaceted interrelations among five dimensions of land, water, organic waste, labour, and food markets (see Fig. 1). We discuss important drivers of change by specifically asking: How do urban and peri-urban farmers respond to challenges and opportunities posed by rapid urban growth?

Based on our analysis, and to guide future research, we conceptualize the multi-dimensional relations between UPA and urban growth as *a wheel of urban growth-related UPA dynamics* (see Fig. 5). To clarify apparent contradictions in the literature, and outline a future research agenda, we further address methodological and analytical challenges in the study of UPA under rapid urban growth. We argue that spatiotemporal dynamics and multi-dimensional complexity pose important challenges. In this context, we show that existing antinomies in the literature stem from diverse methodological approaches, which are variously suited to different kinds and scales of UPA dynamics. To overcome these challenges, our *analytic wheel* calls for more mixed-method research that links multi-temporal, geospatial data to longitudinal qualitative and quantitative fieldwork, in order better understand and critically assess the dynamic and multifaceted socio-spatial changes of UPA across cities of the Global South. Finally, we draw some conclusions and address implications for planning and policy making.

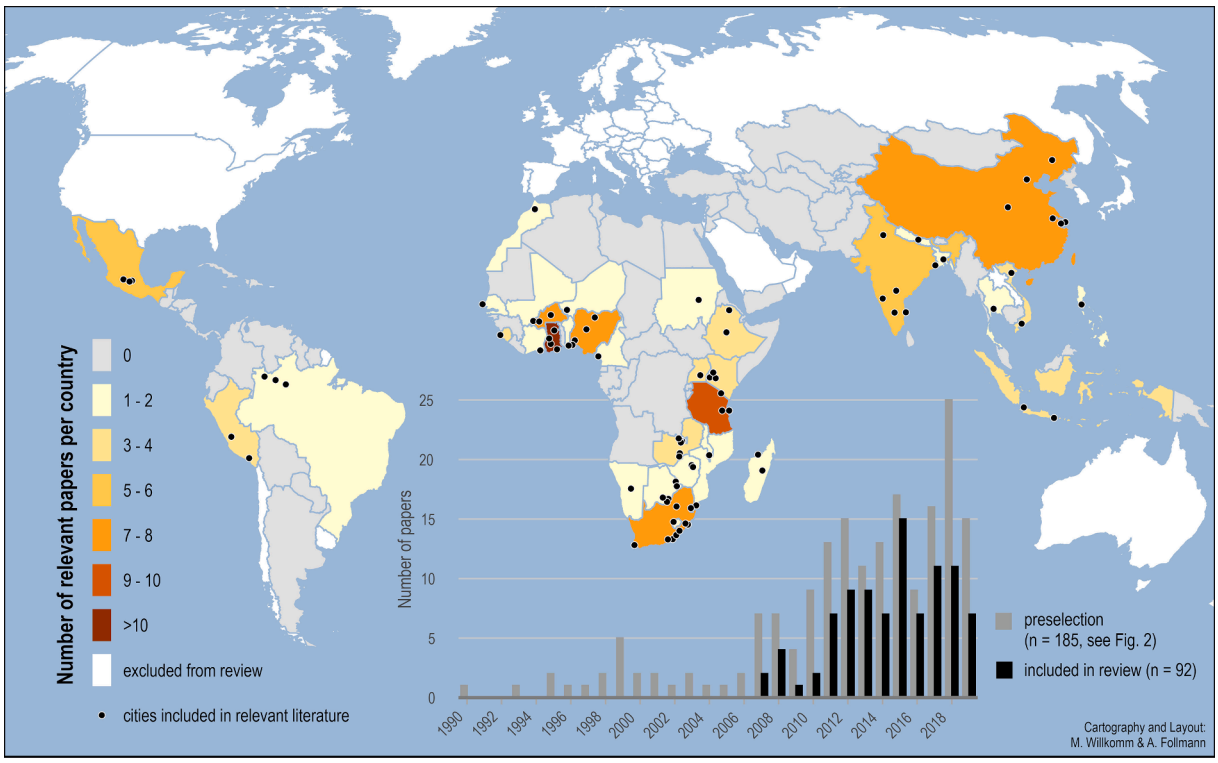

Fig. 3. Geographical distribution of the study areas in relevant empirical articles.

2. Materials and methods

Our systematic review employs a meta-analytic case study approach (Rudel, 2008). To conduct a comprehensive review of peer-reviewed empirical studies on UPA across the Global South – defined according to the list of countries officially receiving OECD development assistance (OECD (2016), excluding European countries – we established an initial database consisting of 3300 candidate articles, which we retrieved by using identical search terms including 'urban agriculture' and synonymic/related terminologies in the bibliographic databases ISI Web of Knowledge and Scopus. Following PRISMA guidelines (Liberati et al., 2009), we identified 92 peer-reviewed empirical articles from 84 research projects reporting on 83 cities (plus one regional analysis, see Appendix C), which explicitly address urban growth-related dynamics according to the five dimensions outlined above. The article selection process is presented in Fig. 2 (see Appendix A for details). In order to systematically analyse the articles, we performed a content analysis using 78 survey questions, which address bibliographical, geographical, theoretical, methodical, and content-related aspects. In Appendices A and B, we provide methodological details on our approach in selecting articles, the review protocol, the survey used, and a list of the final pool of articles.

3. Results

3.1. Descriptive overview of the literature

While the identified articles cover cities in 36 countries, the geographical distribution is uneven, with a bias toward 60 articles focusing on African cities, 24 articles on Asian cities, and only ten articles on Latin American cities (Fig. 3). Only two articles include a comparative analysis of UPA in African and Asian cities. Therefore, the interpretation of our results must be viewed in light of the regional dominance of Africa and the paucity of comparative research. The reviewed studies further focus on various types (subsistence and commercial farming) and different scales of UPA. 42 papers specifically address smallholders, while others include also larger farms.

To analyse methodological approaches of existing empirical research on UPA, we identified quantitative methods, qualitative methods, and remote sensing for data acquisition and GIS-based analysis. Additionally, we checked for mixed methods, comparative, and multi-temporal study designs. Fig. 4a provides an overview of methods used in the articles reviewed across different dimensions. Most studies used quantitative household or farm surveys (59%), qualitative methods (67%), including interviews with farmers and other actors and experts in the agro-food sector (including group discussions), or a mix of both (38%). One third of articles used GIS techniques, and slightly more than one quarter employed remote sensing approaches. A total of 18% articles combined data from social science methods and GIS. Only a few articles used multi-temporal approaches (27%, all focusing solely or mainly on land). This underlines the difficulty of multi-temporal studies on urban growth-related dynamics (cf. Saldaña, 2003).

3.2. Multi-dimensional UPA dynamics under rapid urban growth

In this section, we outline multi-dimensional dynamics affecting UPA and identify general dynamics that recurred in reviewed case studies beyond local settings and across different regions. Fig. 4b offers a quantitative overview of various co-occurrences among the five dimensions.

3.2.1. Land

Land dominates debates on UPA under urban growth, as 80% of articles reported land-related spatiotemporal dynamics. The spatial replacement of UPA was reported in 88% of articles, while 32% indicated spatial expansion, and 42% agricultural intensification (see Fig. 4c; each article focusing on land may include more than one process). By evaluating the criteria/indicators employed, we identified a dominant trend for 41 articles, according to which UPA replacement clearly dominated in 37 articles, while spatial expansion was dominant in three articles (Forkuor & Cofie, 2011; Gbanie, Griffin, & Thornton, 2018; Schumacher et al., 2009) and intensification was only dominant in

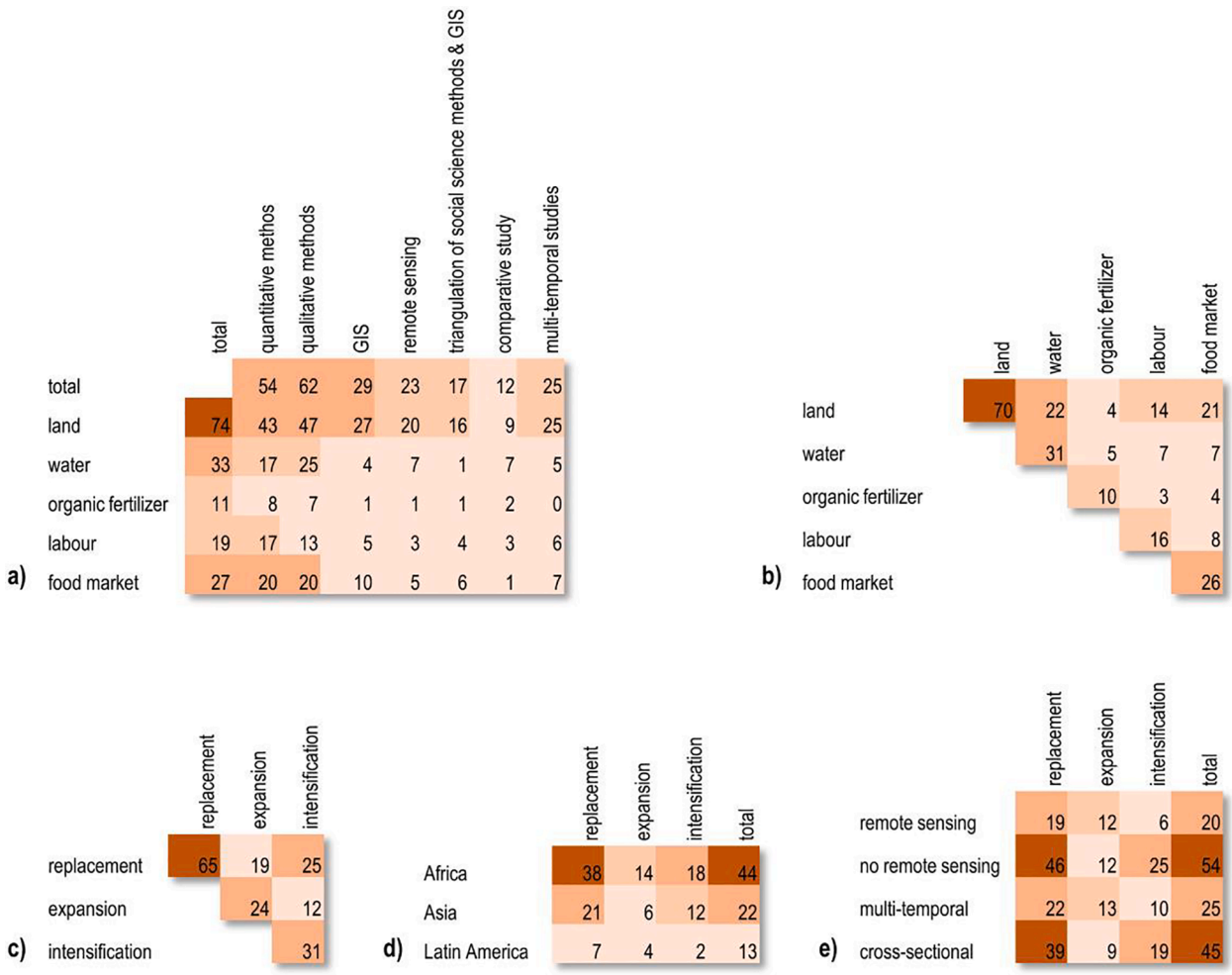

Fig. 4. (a) Methods used for the study of different dimensions; (b) co-occurrence of dimensions (total = land/land, etc.); (c) co-occurrence of land dynamics; (d) land dynamics across regions; (e) methods related to land dynamics (all in number of articles).

one paper (Mawois, Aubry, & Le Bail, 2011). Fig. 4d indicates no significant differences among Africa and Asia in terms of replacement (86% to 95% of the studies identify replacement), spatial expansion (32% to 27%), and intensification (41% to 55%). The number of studies on Latin America is too small to identify clear trends, but most studies indicate replacement, too.

The widespread replacement of UPA is frequently connected to dynamic land use changes, rapid growth of built-up areas, increasing land values, and land conflicts (Nchanji, 2017; Pribadi & Pauleit, 2015; Robineau & Dugué, 2018; Willkomm, Follmann, & Dannenberg, 2019). Land dynamics are often viewed as problematic as uncontrolled, largely owed to a lack of adequate planning capacities and/or urban development policies (Aubry et al., 2012; Debolini, Valette, François, & Chéry, 2015; Haller, 2017; Nchanji et al., 2017). Informal arrangements to use of land for UPA usually dominate (Allen 2013; Padgham, Jabbour, & Dietrich, 2015; Robineau & Dugué, 2018). Farmers are further part of many informal land transactions (Lerner & Appendini, 2011; McLees, 2011; Simiyu, 2013).

The co-occurrence of replacement, expansion, and intensification (see Fig. 4c) confirms intra-urban variations, and underlines the complexity of urban growth-related impacts on UPA. For example, Drechsel and Dongus (2010, p.73) conclude for Dar es Salaam (Tanzania) that "[t]he overall amount of cultivated open spaces has basically remained the same […], whereas the locations of the agricultural areas have changed considerably". In this context, a number of studies indicate *peripheralization* of agricultural uses (Babo, 2010; Haller, 2014, 2017; Kuusaana & Eledi, 2015; Mackay, 2018; Pribadi, Zasada, Muller, & Pauleit, 2017).

Babo (2010) argues that "[u]rban agriculture in Abidjan is being progressively transformed into periurban agriculture, with new producers and sellers changing the process of production and commercialization". Similarly, Mackay (2018, p.196) outlines how Ghanaian city planners view agriculture as "mov[ing] to *peri*-urban areas as the city develops and land prices rise", whereas Kuusaana and Eledi (2015, p.462) warn that "farmers are being pushed unto less favourable lands, farther villages or restricted to unauthorised public spaces". Whether creating new opportunities, or resulting in the marginalization of farmers, the peripheralization of UPA is connected to intensification and commercialization processes, eventually resulting in new and changing farming types. Reporting on Kampala (Uganda), for example, Vermeiren, Adiyia, Loopmans, Tumwine, and Van Rompaey (2013, p.46) indicate that "urban sprawl on the one hand is expected to have negative consequences for subsistence farmers that are expected to lose up to 80% of their land, while the space for garden and commercial farming activities would even increase with almost 40% by 2030".

Individual choice is further presented as a reason for replacement, as farmers abandon UPA in a search for non-agricultural employment (Lerner & Appendini, 2011; Mosha, 2015). However, farmer responses depend on their socio-economic status and existing land tenure regimes. While *land-secure* farmers (using private land with some type of formal land title) might invest in various agricultural or non-agricultural uses (e.g. housing), *land-insecure* farmers – in particular smallholders – who

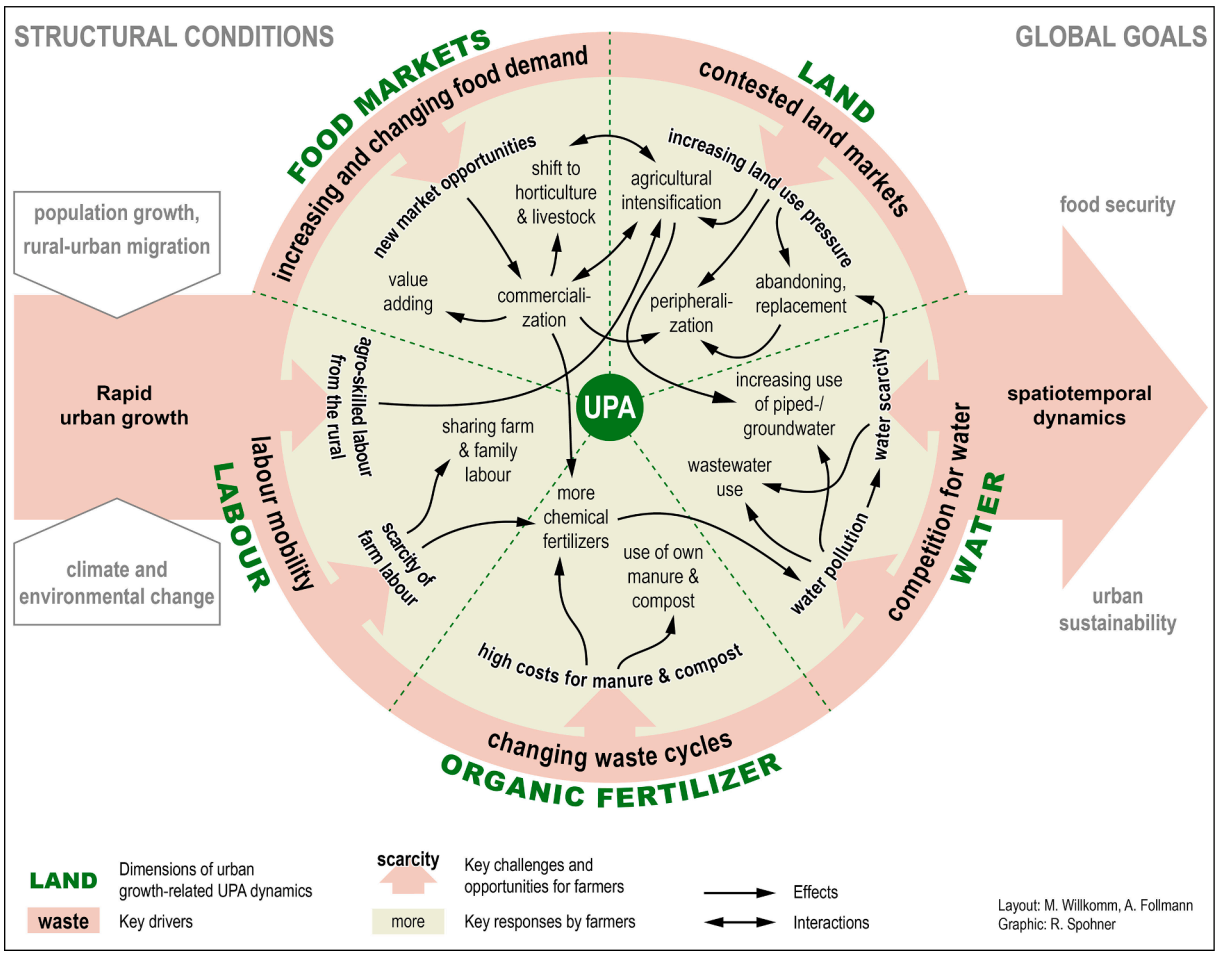

Fig. 5. The wheel of urban growth-related UPA dynamics (with most important intra- and interdimensional relations identified from the reviewed literature).

lease land or who are without any formal land titles (e.g. customary land, informal use of public land) face increasing struggles (Cobbinah et al., 2015; Haller, 2014; Schmidt, Magigi, & Godfrey, 2015). These latter farmers try to organize in groups, cooperatives, or other formal and informal networks to claim land rights (Babo, 2010; Robineau, 2015) or to informally use public land (Kuusaana & Eledi, 2015; Simatele & Binns, 2008). Besides direct pressures from urban growth, land dynamics are connected to shifting agricultural policies (Lerner & Appendini, 2011) and changing land governance, e.g. processes of formal titling (Bellwood-Howard, Shakya, Korbeogo, & Schlesinger, 2018; Nchanji, 2017).

Drivers for spatial expansion and UPA intensification are increasing and changing demand for food (Korbeogo, 2018; Mawois et al., 2011; Nchanji et al., 2017). Yet, these processes have ecological consequences, as spatial expansion and peripheralization often occur at the expense of ecologically-sensitive areas, e.g. forests or wetlands (Pribadi & Pauleit, 2015; Robineau & Dugué, 2018). Intensification results in, among others, increasing use of inorganic fertilizer and pesticides (Hussain & Hanisch, 2014). In addition, loss of agricultural land and intensification are often linked. Robineau and Dugué (2018, pp.52–53), for example, show that farmers in Bobo-Dioulasso (Burkina Faso) "commonly attempt to intensify their farming activities as a compensation for the loss of food-growing fields," especially if they receive compensation money to invest and own "non-buildable" land with access to water resources. Similar investments in livestock are mainly made by wealthier urban (non-)farming dwellers in order to "supplement their income or prepare for their retirement" (Robineau & Dugué, 2018, p.55; cf. Schmidt et al., 2015).

Overall, only a few studies explicitly report on farmers' responses, and rather focus on the effects of urban growth on UPA. Exceptions include studies on Jabodetabek Metropolitan Area (Indonesia) (Pribadi et al., 2017), Ho Chi Minh City and Hanoi (Vietnam) (Nguyen & Kim, 2019; Nguyen, 2011), and Hyderabad (India) (Hussain & Hanisch, 2014).

3.2.2. *Water*

Water dynamics affecting UPA are discussed in 31 articles. All report on mounting water-related challenges, either quantitatively in terms of (seasonal) water scarcity, or qualitatively in terms of pollution/contamination. Four urban growth-induced causes are identified frequently: First, growing urban populations demand higher volumes of fresh water for different usages. This results in water scarcity as well as overexploitation of surface (Taiwo, 2014) and ground water sources, potentially leading to salinization of ground water (Lagerkvist, Ngigi, Okello, & Karanja, 2012; Padgham et al., 2015). Second, often informal industrial development and domestic water use cause increasing water pollution (Kapungwe, 2011; McLees, 2011, 2013). Third, we found the often-informal conversion of water bodies into built-up areas (Gumma, Mohammad, Nedumaran, Whitbread, & Lagerkvist, 2017), and the destruction of irrigation systems due to urban development (Nguyen, 2011). Fourth, different studies identify urban growth-induced agricultural intensification, and transformation of rain-fed into irrigated cropping, as contributing factors (McLees, 2013).

In sum, a number of articles address water scarcity as *the* key challenge. Yet, in some cities, urban growth is related with better water infrastructures (e.g., availability of piped water, and treated waste water for irrigation), and thus improved farmer access to water (Mosha, 2015; Owens, 2016).

In terms of responses, better-off farmers are able to proactively invest in water sourcing and irrigation (Hussain & Hanisch, 2014). However, in most cases, farmers lack financial resources and their responses are rather reactive, including only farming during the rainy season, leaving land fallow (Nguyen, 2011), using piped water at high costs (McLees, 2011), storing water in dams/pits (Bisaga, Parikh, & Loggia, 2019; Mosha, 2015), increasing use of (untreated) waste water or other informal arrangements to access water – with related health and environmental problems (Korbeogo, 2018; Nchanji et al., 2017; Padgham et al., 2015). In some cities, farmers are forced to abandon or relocate UPA activities due to failing access to water (Foeken & Owuor, 2008; Taiwo, 2014). Urban growth-related water challenges are often linked to broader environmental and climate changes (Padgham et al., 2015; Taiwo, 2014), and increasing water scarcity is projected for the future (Schumacher et al., 2009).

3.2.3. Organic fertilizer

Few articles address urban growth-related dynamics in organic fertilizer use. Organic waste recycling by farmers is generally an informal activity (Hofmann, 2013). Important drivers for shifts from organic to inorganic fertilizer use are rising proportions of inorganic waste in the urban waste composition (e.g., more plastic use), resulting in higher costs to separate organic waste matter, increasing competition over waste as a resource (e.g., energy, recycling, etc.), and urban governance reforms to formalize and privatize waste management (Hofmann, 2013). Additionally, many farmers turn to inorganic (e.g., chemical) fertilizers due to increasing labour costs and land restrictions.

While composting of organic urban waste declines, intensified livestock farming requires proper manure management to avoid environmental degradation (Lupindu, Ngowi, Dalsgaard, Olsen, & Msoffe, 2012; Mireri, Atekyereza, Kyessi, & Mushi, 2007). This results in an oversupply of manure in some locations, while non-livestock farmers in other locations face manure shortages due to high transport costs (Bellwood-Howard et al., 2018; Robineau, 2015). In response to these locally-varying dynamics, some UPA farmers try to reuse more organic materials from their farms (e.g., crop residues) or keep livestock on site for their manure. Roessler, Mpouam, Muchemwa, and Schlecht (2016, p.18) report that livestock farmers tend to sell manure to vegetable farmers in Ouagadougou (Burkina Faso), while this business is hampered by cheap inorganic fertilizer in Tamale (Ghana). In the city of Bobo-Dioulasso, Robineau (2015, p.326) describes how informal manure markets depend on "carters" to transport the manure, and existing mutual aid networks among livestock and vegetable farmers. In sum, urban growth-related dynamics for organic waste and manure use in UPA depend on highly specific local contexts, and geographical arrangements.

3.2.4. Labour

The literature reveals two opposing trends in labour dynamics: On the one hand, farmers face labour scarcity and increasing labour costs, due to increasing competition from other sectors (e.g., construction industry; Hofmann, 2013; Hussain & Hanisch, 2014). Moreover, particularly in Asia, younger urban dwellers seek to work outside agriculture (Ding, Liu, & Ravenscroft, 2018). On the other hand, availability of labour improves as rural–urban migration brings agro-skilled workers to the city (Kuusaana & Eledi, 2015; Pribadi & Pauleit, 2015, 2016; Taiwo, 2014). Responding to these dynamics, farmers adapt their choice of crops and cultivation methods toward less labour-intensive production (Nguyen & Kim, 2019), or shift to high-value products to compensate for increasing costs (Hussain & Hanisch, 2014). Additionally, farmer organizations are formed to mobilize (young) skilled labour (Maconachie, Binns, & Tengbe, 2012). Others concentrate more on family labour, and temporarily help one another through labour-sharing and other mutual aid relations (Hussain & Hanisch, 2014; Mendez-Lemus & Vieyra, 2017). Although some of these outlined labour dynamics are recognized across different regions, these usually informal labour-related dynamics are mixed and vary depending on local contexts.

3.2.5. Food markets

Across the Global South, studies outline rising and changing demand for fresh, nutrient-rich, high-quality foods, in particular, vegetables and livestock products, as well as exotic foods and fast/street food – some of which might be prepared by farmers (Aubry et al., 2012; Emperaire & Eloy, 2015; Hussain & Hanisch, 2014). Authors generally link these to population growth as well as improvements in wealth distribution and changing lifestyles (Nchanji, 2017). Urban farmers seek to intensify production to meet these demands, shifting production from staple foods to high value crops, while pursuing value-adding practices (Aubry et al., 2012; Boué, López Ridaura, Rodríguez Sánchez, Hellin, & Fuentes Ponce, 2018; Mawois et al., 2011). Other farmers enhance livestock production (e.g., zero-grazing) to serve rising markets for perishable meat produce (Katongole et al., 2012). The upgrading of urban infrastructures (e.g. transportation systems, wholesale markets, etc.) can improve farmers' access to markets (Owens, 2016). However, smallholders especially face increasing barriers to market access (Mun Bbun & Thornton, 2013; Nchanji, 2017) and informal food marketing remains the norm (Roessler et al., 2016; Sanusi, 2014). Cooperative-building is one common response to such constraints (Maconachie et al., 2012; Nchanji, 2017; Yang et al., 2016). In sum, urban growth demands more and higher quality food, which can provide new market opportunities for UPA.

3.3. Multi-dimensional linkages

In order to better understand the complexity of the urban growth-related UPA dynamics, we analyse multi-dimensional linkages. Although a couple studies report on different dimensions (see Fig. 4b), few articles specifically address such interlinkages empirically. Linkages between land and water are particularly researched. The use of land for intensified agriculture is spatially linked to water sources, such as floodplains (Korbéogo, 2018; Robineau & Dugué, 2018), and farmers are often forced to relocate due to water inaccessibility (Taiwo, 2014). Yet, increasing urban pressures and climate-change impacts (e.g., flooding) will likely constrain such uses, and the insecurity of land prevents more long-term investments, such as for irrigation (Padgham et al., 2015, p.191). Floods can further "spread untreated water over the farms and contaminate wells" (McLees, 2011, p.609).

Beside spatial links, water is also institutionally linked to land. For example, Korbeogo (2018, p.284) argues that "[g]overnance of water resources is intimately embedded in land tenure systems", and land reforms "have led to shifting norms and technologies of land and water use" for UPA in Burkina Faso.

Land-labour linkages are reported as land fragmentation and shrinking farm sizes result in reduced need for agricultural labour (Taiwo, 2014). However, processes of crop change and production intensification challenge this straightforward relation, and the increased use of agro-chemicals are direct responses by farmers to increasing labour shortage and costs, amongst other things (Hussain & Hanisch, 2014; Nchanji et al., 2017; Taiwo, 2014). Additionally, Korbeogo (2018, p.298) observed that increasing use of agro-chemicals "is linked to the demand for fresh vegetables with green and non-perforated leaves, which are aesthetically attractive for urban consumers."

Nguyen and Kim (2019, p.102) offer another example, observing how labour scarcity, aging farmers, and land pressure jointly influence the choice of crops. For peri-urban Ho Chi Minh City, they explain that farmers turn to lime cultivation, as "lime appeared suitable in dealing with a situation of labour shortage and low access to land", while providing a "continuous flow of income" that matched the locally available labour supply of older farmers who preferred light work (ibid.).

Across all five dimensions, informal arrangements provide an important frame within urban and peri-urban farmers operate. Informal arrangements are often multi-dimensional: For example, the informal status of land or UPA's informality as such (e.g. being forbidden in urban

bylaws) often necessitate other informal arrangements, e.g. informal water access (Drechsel & Dongus, 2010), or even force farmers to please their neighbours by giving them products for free (Robineau, 2015).

3.4. Policy recommendation from existing research

As about two-thirds of the reviewed articles provide policy recommendations, much of the existing literature on UPA under urban growth is policy-oriented. The reviewed literature indicates that policies regulating and supporting UPA greatly vary, and UPA is not often integrated into urban planning. In many cities, municipal bylaws even prohibit UPA. In response, a large number of authors recommend integrated planning approaches that would legalize UPA, provide secure land tenure, and conserve highly productive farmland (cf. Cobbinah et al., 2015; Kuusaana & Eledi, 2015; Padgham et al., 2015; Sanusi, 2014). However, such an approach is criticized by Robineau and Dugué (2018, p.56) for having disparate effects that may only benefit "certain privileged populations". Similarly, Mackay (2018, p.196) asks if moving away from "rigid zoning" may help UPA, as urban administrations "are often under-resourced to enable such" policies. Thus, other authors argue for more participatory forms of governance (Debolini et al., 2015; Nchanji, 2017) and better inter-sectoral coordination in urban governance (Mireri et al., 2007; Robineau, 2015). The informal status of UPA and institutional ambiguities are widely acknowledged as governance challenges (Drechsel & Dongus, 2010; Lerner & Appendini, 2011; Nchanji & Bellwood-Howard, 2018).

4. Discussion

4.1. Reconceptualizing UPA-urban growth relations: a wheel of urban growth-related UPA dynamics

Our review findings indicate complex, multi-dimensional, and dynamically-changing linkages between UPA and rapid urban growth. Based on these findings, and in order to develop a holistic framework, we integrate and reconceptualize our findings as a *wheel of urban growth-related UPA dynamics* (see Fig. 5), highlighting important urban growth-related effects on UPA and responses by farmers. The UPA-urban growth relations are reconceptualized as an analytic wheel to indicate internal spatiotemporal dynamics, and to highlight how dynamics in one dimension may set dynamics in motion across other dimensions. Additionally, existing systems of governance as well as informal arrangements (might) change and directly affect UPA-urban growth relations across all dimensions.

Review results indicate that contested formal and informal land markets, increasing competition for water, changing urban waste cycles, labour mobility, and increasing and changing food demand are key drivers for UPA transformation. In particular, scarcity and fragmentation of agricultural land pose key challenges across all city-sizes and regions, and affect other dimensions in multiple ways. In this context, we have identified three land-related spatiotemporal responses of farmers that often occur in tandem with one another: 1) replacement of UPA in areas with high urban development pressure; 2) agricultural intensification, particularly in areas unfit for urban development, but with (good) access to water (e.g., along rivers); and 3) spatial expansion of UPA on the outskirts – often transforming ecologically-sensitive lands into farmland. By spatiotemporally linking replacement and expansion across city territories, we find that the *peripheralization* of UPA emerges as a widespread phenomenon. These findings confirm quantitative and qualitative studies of peri-urban land use changes across the Global South (Abass et al., 2018; Pandey & Seto, 2015; Zoomers et al., 2017). However, our explicit focus on farmers' responses shows that farmers are not a priori *passive spectators*, or even *victims* of urban growth; instead, depending on individual resources and local conditions, they are able to actively shape peri-urban transformations through individual (or coordinated) decisions to either abandon, shift, intensify, or expand farming. Thus, farmers remain important land owners/holders, but their role in agro-urban land conversion processes may depend on land tenure status (Cobbinah et al., 2015; Padgham et al., 2015; Schmidt et al., 2015). In this context, our review results confirm that the conversion of agricultural land does not purely follow economic laws, but rather that UPA spatiotemporal continuity is linked to different motivations to continue farming, but also specific familiy constellation (e.g., descendents needing land to build residences, Lerner & Appendini, 2011, p.99) can trigger abandonment of farming. In line with Lerner and Eakin (2011), the studies we reviewed highlight dimensions of self-sufficiency, livelihood diversification, and cultural traditions (Foeken & Owuor, 2008; Lerner, Eakin, & Sweeney, 2013; Owens, 2016).

As our review shows, we also need to develop better understanding of the multi-dimensional complexity of farmers' decision-making processes, and spatiotemporal dynamics farmers have to deal with, both spatially and institutionally (cf. Thebo et al., 2014). For example, land insecurity may push farmers to choose short- over long-term profits, which in turn may affect other dimensions and decisions in multiple ways (e.g. use of chemical fertilizer or waste water), thereby challenging the sustainability of UPA in such contexts (Nchanji, 2017).

The studies generally acknowledge access to water, which is often closely connected to land, as a key resource determining spatiotemporal distributions of UPA, thereby explaining intra- and inter-urban variations in UPA dynamics. The *analytic wheel* highlights spatial and institutional links between land and water, as outlined in the broader literature on peri-urbanization processes across the Global South (cf. Sreeja, Madhusoodhanan, & Eldho, 2017).

With respect to urban waste as fertilizer, our findings indicate that changes in the urban waste sector result in a diminishing role of organic urban waste composting in UPA – sometimes linked to land and labour scarcity (Hofmann, 2013). Our review thus confirms findings of policy-oriented literature (see e.g. FAO, 2012), and expands the general view that the substitution of organic materials is driven by increasing market penetration of high-input technologies (e.g., synthetic fertilizers, chemical pesticides, etc.) with a specific urban growth-related perspective. Yet, organic waste dynamics are not well-understood, as very few studies address this dimension (most importantly, Hofmann, 2013).

At first glance, urban growth-related labour dynamics in UPA paint a clear picture: spatial replacement of UPA releases agricultural labour, which is absorbed in the emerging urban economy (Steinhübel & von Cramon-Taubadel, 2021). Yet, contrary to this conventional wisdom, our review shows that UPA labour dynamics vary considerably, depending on local contexts and individual motivations for farming (cf. Lerner & Eakin, 2011). In particular, the high importance of family labour, part-time or even seasonal UPA business structures, livelihood risk management strategies, as well as methodological challenges in measuring UPA labour intensity, all further complicate this picture. Therefore, our review suggests that more attention needs to be paid to labour dynamics. In particular, more comparative research is necessary in order to identify determining factors, as results across cases appear contradictory.

On the demand side, our review confirms that urban growth offers greater market opportunities and can foster economies of scale, resulting in interlinked commercialization and agricultural intensification. While about one-third of the reviewed articles mention these dynamics, detailed empirical studies on UPA responses are rare. Interestingly, while newly emerging, short agri-food value chains are prominently discussed as niche opportunities (Moustier & Danso, 2006; Moustier & Renting, 2015), these shorter value chains play a minor role in reviewed cases. By contrast, local traders, street vendors, and wet markets continue to be dominant marketing channels (rather than supermarkets, groceries, etc.), and market access remains an important challenge for UPA, despite increasing demand (Cabannes, 2012; Maconachie et al., 2012; Mun Bbun & Thornton, 2013). As a result, better-off and more affluent farmers tend to benefit, as they have greater capabilities, land,

water, and financial resources available to them.

Interestingly, while some reviews (De Zeeuw et al., 2011; Orsini et al., 2013) indicate high market shares of UPA in fresh foods, the cases we reviewed generally refrained from quantifying UPA production at the city level. Recent studies focusing on urban/regional foodsheds (Karg et al., 2016) may offer insight in quantifying the importance of UPA under urban growth.

Beyond these general trends, studies examining the multi-functionality of UPA (Zasada, 2011) indicate urban-growth related processes from other parts of the world, including on-farm processing, direct sales of farm products, such as prepared fast/street food, and agro-tourism activities (Drechsel & Dongus, 2010; Pribadi et al., 2017). The "conversion of production landscapes to recreational landscapes" is a common phenomenon in Europe (Shaw, van Vliet, & Verburg, 2020, p.6), and also identified in China (Yang et al., 2016). Therefore, our review findings also point toward a convergence of UPA in the Global North and South (cf. Gray, Elgert, & WinklerPrins, 2020), which is shaped by different "models-in-circulation" (Schwab, Caputo, & Hernández-García, 2018), as UPA turns into more-than-food-production, at least in some Asian cities.

4.2. Methodological and analytical challenges: spatiotemporal dynamics and multi-dimensional complexity

In contrast to Zezza and Tasciotti (2010, p.265), who argued that a better understanding of UPA is "hindered by a lack of good quality, reliable data", the review has shown that the geographical and methodological scope of UPA studies is wide. Nevertheless, our analysis indicates several analytic challenges. In particular, studies focusing only on particular city neighbourhoods often overlook UPA dynamics at other scales and in other places. For example, while all four studies focusing on land in Dar es Salaam (Drechsel & Dongus, 2010; Halloran & Magid, 2013; McLees, 2011; Owens, 2016) observed processes of UPA replacement, the only study informed by multi-temporal remote sensing (Drechsel & Dongus, 2010) identified spatial expansion of UPA. Additionally, the qualitative study by McLees (2011) at four specific sites, and the survey-based study by Owens (2016) on two peri-urban settlements, both indicated agricultural intensification.

Similarly, remotely-sensed data for Hyderabad, India (Lagerkvist et al., 2012) and Jabodetabek Metropolitan Area, Indonesia (Pribadi & Pauleit, 2015) detected spatial expansion of UPA, whereas non-geospatial research on these cities did not find similar evidence for this (Hussain & Hanisch, 2014; Pribadi & Pauleit, 2016; Pribadi et al., 2017). Furthermore, our quantitative analysis (see Fig. 4e) reveals that studies using remote sensing identified UPA expansion in 60% of cases, whereas studies without remote sensing identified expansion in only 20% of cases. Similar, multi-temporal studies (partly overlapping as 18 of the multi-temporal studies use remote sensing) identify UPA expansion in 52% of cases, while studies relying on cross-sectional data identified expansion in only 20% of cases. Thus, we argue that remotely-sensed, multi-temporal approaches more often detect UPA expansion than studies using other methods. Conversely, contradictory empirical evidence in literature on UPA under urban growth can be accounted for by diverse methodological approaches and different scales of analysis.

As many studies lack data on land use change, we suspect that many studies overlook agricultural expansion, especially at the periphery. Most recent remotely-sensed studies, both on UPA (Karg, Drechsel, Dittrich, & Cauchois, 2020; Willkomm, Follmann, & Dannenberg, 2020 and peri-urban land transformations (Abass et al., 2018), show that while agricultural land may be converted to urban built-up in central locations, forested lands are transformed into agricultural land on the periphery. Given this dynamic, we argue for more remotely-sensed, multi-temporal studies at the city or regional scale to identify the spatiotemporal juxtaposition and intra-urban variations of replacement and expansion.

Moreover, it is important to triangulate these findings with detailed on-the-ground research in order to better understand complex UPA transformations under urban growth. Yet, as current studies mainly rely on cross-sectional surveys, we also argue for longitudinal studies (e.g., panel studies) to analyse long-term effects of urban growth on UPA.

Beyond the methodological and scalar challenges outlined above, we see a need for more comparative research to better explain contradictory evidence about UPA under urban growth. We propose our *analytic wheel* as a conceptual frame to guide empirical research, as it highlights multiple interlinkages among different dimensions of change. In this review, we have identified multiple connections between land and other agricultural production factors, and our results further confirm the existence of close linkages in access to water and land in peri-urban areas (cf. Sreeja et al., 2017). Additionally, we argue that multiple interconnections exist across other dimensions. Yet, as many studies focus *exclusively* on land, other dimensions – in particular, organic waste, labour, and market dynamics – are so far under-researched. Future research on UPA needs to move beyond this land-focused – or even land-locked – view to pay more attention to interlinkages among other dimensions.

In summary, our *analytical wheel* highlights the need for critical longitudinal research on UPA (Robineau & Dugué, 2018; Tornaghi, 2014), with particular sensitivity to geographical scale and multi-dimensional complexity in order to foster a more holistic analysis of the spatiotemporal dynamics of UPA under urban growth.

4.3. Implications for planning and policy making: governance challenges

The complex UPA-urban growth relations pose multiple challenges for policy making and planning. These governance challenges are acknowledged in global UPA policy discourses (FAO, 2012), and have been partly addressed in more policy-oriented reviews (Hamilton et al., 2014). Consistently with these, the reviewed literature indicates multiple and interlinked governance challenges of UPA under urban growth emphasizing the importance of policy-oriented research. However, as many studies focus on the effects of urban growth on UPA rather than responses by farmers, policy recommendations mirror this focus and mainly concentrate on regulative (land and water) policies to *save* UPA from (informal) rapid urban growth. Additionally, as many studies focus on land, policy recommendation are often also land-focused. Here our review calls for more (policy-oriented) research focusing on the needs of urban and peri-urban farmers and ways to integrate UPA in sustainable urban development (De Zeeuw et al., 2011). Existing urban policies in many cities of the Global South aim for eradicating informality, and, thereby, also tackle UPA as farming is (still) viewed as backwards, economically poor and 'rural' (Feola, Suzunaga, Soler, & Wilson, 2020). In this context, our *analytic wheel* offers a conceptual frame for assessing taken-for-granted assumptions about UPA – including the *a proiri* set goal to eliminate informal UPA activities. It allows to critically scrutinize existing governance arrangements and specific policy recommendations in order to assess whether existing UPA is indeed problematic (e.g., due to ecological or health risks) or whether UPA under certain regulations may indeed be beneficial and desirable with regard to food security and urban sustainability in cities of the Global South (cf. De Bon et al., 2010; Feola et al., 2020). In particular, the framework urges researchers and policy makers to think beyond one-dimensional and single-sectoral interventions, and rather to stress interdimensional linkages and multi-sectoral governance responses.

5. Conclusion

This systematic review (1) provided a comprehensive overview of existing case study-based knowledge of UPA, focusing on and identifying general dynamics of UPA under rapid urban growth; (2) reconceptualized the spatiotemporal dynamics of UPA under urban growth as a *wheel of urban growth-related UPA dynamics*; and (3) identified existing methodological and analytical challenges in the study of UPA under

urban growth, as well as outlined implications for planning and policy making.

First, we have shown that urban growth across the Global South results in multiple challenges for UPA across local agricultural production factors, whereas increasing and changing food demand offers new opportunities for UPA in many cities. In particular, agricultural land conversion and peripheralization of UPA are widespread across all regions. Additionally, a number of studies indicate spatial expansion and intensification, in particular in Africa and Asia, as a response to increasing and changing food demand. Urban growth-related dynamics in the availability of water, organic fertilizer, and labour can further foster or constrain UPA. Consequently, farmers (are forced to) respond and adapt to urban growth in multiple ways: Land-and-water secure farmers benefit from intensification and commercialization, while marginal farmers often face increasing difficulties to (informally) access land and other agricultural production factors. Thus, while our review confirms expected results, some findings indicate that farmers are not a priori *passive spectators* or even *victims* of urban growth; farmer responses rather depend on their resources and specific local conditions.

Second, by taking the multi-dimensional and dynamically-changing interlinkages of UPA and urban growth into account, we have developed a new conceptual framework to guide future UPA research, which we call the *wheel of urban growth-related UPA dynamics*. In this context, future research may address multi-dimensional questions of governance and informality of UPA to both control and enable UPA in cities of the Global South.

Third, in relation to this framework, and with respect to existing methodological and analytical challenges identified, we have highlighted spatiotemporal dynamics and complex multi-dimensionality as important challenges for both empirical research as well as policy and planning. We have argued that apparent contradictions in the literature often stem from diverse methodological approaches, which are differently equipped to unveil UPA dynamics at multiple spatial and temporal scales. To overcome these challenges, and to apply this framework, we call for more mixed-method research linking multi-temporal, remotely sensed data to longitudinal qualitative and quantitative field data.

Finally, if the contribution of UPA to global food security and urban sustainability goals is to be maintained or even expanded, we argue that the empirical evidence presented in this review suggests that planners and policy-makers should rethink extant UPA policies in terms of spatiotemporal dynamics, multidimensional complexity, and intra-urban variations.

CRediT authorship contribution statement

Alexander Follmann: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - original draft, Visualization, Project administration. **Maximilian Willkomm:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - original draft, Visualization. **Peter Dannenberg:** Conceptualization, Resources, Writing – review & editing, Supervision.

Acknowledgements

The authors are thankful to Johanna Fellbrich for her help in generating the article database for the systematic review and Jonathan DeVore for proofreading. We gratefully acknowledge the comments of the anonymous reviewers who considerably helped to improve the paper. Funded by the German Research Foundation (DFG) through the collaborative research center “Future Rural Africa”, funding code TRR 228/1.

Appendices A–C. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.landurbplan.2021.104186.

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