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THE IMPLICATIONS OF URBANIZATION ON PERI-URBAN LAND-USE CHANGE: A LITERATURE REVIEW

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Abstract

This is an integrative review of land-use science literature, focusing on the common areas of land-use change research; urbanization and land-use change, peri-urbanization and the land-use sustainability at the city fringes. Also, it discusses the developed concepts among the land-use research community for synthesizing the peri-urban land transition phenomena, parallel to the contemporary urbanization presence. This qualitative review summarises the land-change science developed pathways in Land system science approach; such as exploring land change drivers, peri-urban land-use sustainability, but not limited to critically discussion of the literature, identifying the methodological problems at different geographies while spotting knowledge gaps in the topic area.

Keywords: *urbanization; peri-urban; land-use; sustainability; land system science*

1. HUMAN–ENVIRONMENT LAND SYSTEMS

Humans have used land and changed land-use to satisfy various expectations throughout millennia (figure 1) (Millington, 2012). During the last few decades, land-use and land-cover change (LULCC) research, ranging from local case studies to global scale analyses (Verburg et al., 2015), has demonstrated the effects of human contact on natural environments. The global LULCC monitoring studies show the significant effect of human intervention as it alters terrestrial ecosystems to satisfy rising demands for food, water, energy and other resources and services (Alexander, Brown, Arneth, Finnigan, & Rounsevell, 2016; Foley et al., 2005; Gutman, 2004; Ramankutty & Foley, 1998; Ramankutty et al., 2006; Seto, Güneralp, & Hutyra, 2012; Seto & Satterthwaite, 2010). On the other hand, cities in Germany and Japan have experienced shrinking urban areas due to demographic and socio-economic changes (Lauf, Haase, & Kleinschmit, 2016; Matanle & Rausch, 2011).

The definition of "urban" is ambiguous and controversial in the land-change science literature (Batty, 2015; Elmqvist et al., 2013b). In their recent epistemological study, Brenner and Schmid (2015) argue against the conventional definition of the term "urbanization" by demonstrating the effect of human intervention beyond the city fringes around the world. Furthermore, their study demonstrates that urbanization offers insights into the socio-economic and ecological systems entangled with LULCC (Acuto, 2015). The above facts demonstrate human involvement with LULCC in world regions, but still leave knowledge gaps on LULCC occurrence, for example, its scale, rate and space, due to its complexity. The land-use research

community faces the challenge of finding the human causes and situations that create a substantial impact on natural environments (Elmqvist et al., 2013b; B. Turner, Meyer, & Skole, 1994; Calota & Patru- Stupariu, 2019) in order to improve the knowledge on land-use transitional phenomena.

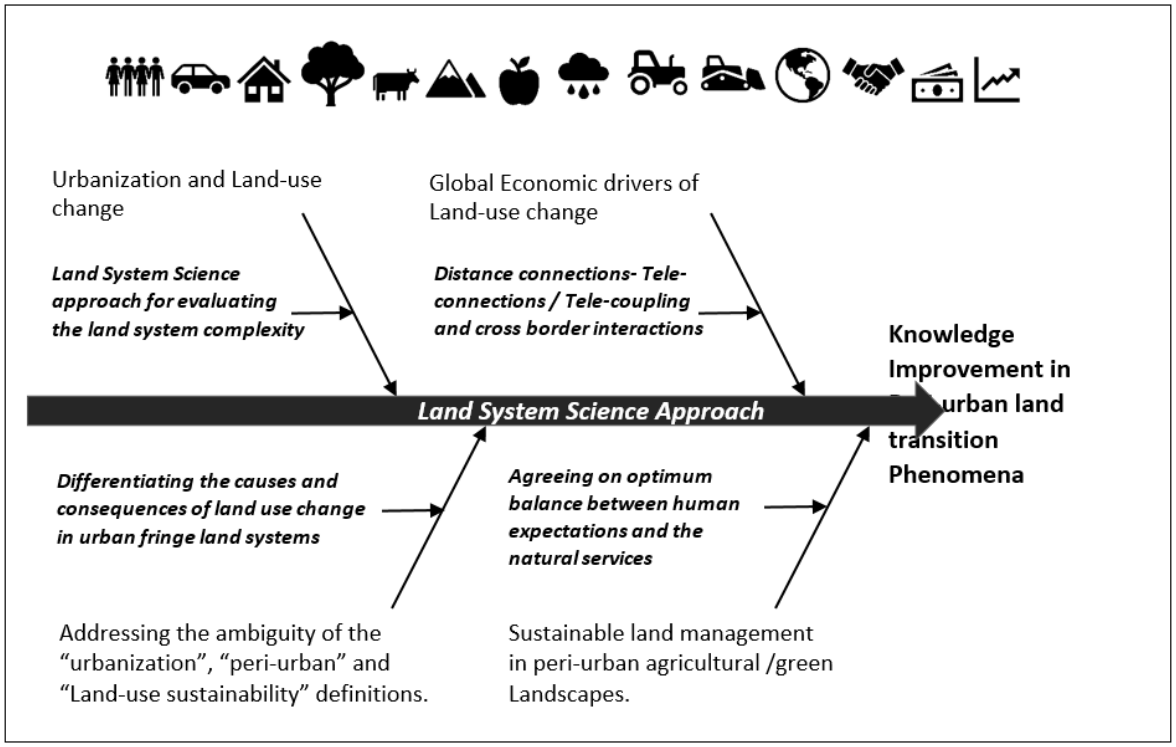

Figure 1. Human - environment land system

Land system science (LSS) is emerging as an inter-disciplinary research area that focuses on LULCC dynamics in human–environment land systems (B. L. Turner, Lambin, & Reenberg, 2007). Described as a holistic approach with insights on bio-physical and socio-economic aspects, LSS is used to analyse complex LULCC in various land systems (Rindfuss et al., 2008; Verburg et al., 2015). The LSS approach has been widely accepted and utilized by land-use researchers for the exploration of LULCC drivers and their impacts on surrounding natural environments, while proposing strategic policy directions for effective land management in rural and urban land systems.

Turner II (2016) explained the use of LSS in land-change research on different land systems:

Land system science (LSS) has expanded its research focus from the drivers of land use and cover change primarily in rural wildlands to include the social-environmental consequences of this change, urban areas, and sustainability practice (Turner II, 2016, p.689).

The use of LSS has significant advantages over traditional land-use change studies, as it is able to offer comprehensive solutions including adaptations and mitigations for global land-change problems, thus leading to sustainable land management practices (Lambin & Geist, 2006; B. L. Turner et al., 2007; Verburg, Erb, Mertz, & Espindola, 2013). The multi-disciplinary approach of land system science (LSS) can be used when researching complex land-transition processes that occur in human-dominant land systems, such as cities and city peripheries.

2. URBANIZATION AND LAND-USE CHANGE

The economic aspects of societies demonstrate a significant contribution to LULCC

occurrences in different geographies worldwide. The comparison of global case studies by Lambin et al. (2001) showed that markets and economic policies are major contributors to creating opportunities and constraints for LULCC, thus rejecting the conventional understanding that population and poverty are the key drivers of LULCC occurrences worldwide. Contemporary globalization trends have created new economic geographies: direct foreign investments; financial agreements between cities in different countries; and cross-border commodity supply chains, while increasing international trade, logistics and services worldwide (Lambin & Meyfroidt, 2011; Millington, 2012; Roberts, 2014; G. M. Robinson & Carson, 2015). The new global economic trends have accelerated LULCC in developing countries, such as, China, India, Indonesia and Vietnam, demonstrating significant urbanization trends due to rising economic opportunities. Most of these countries, including China, use urbanization as a policy instrument to achieve their country's economic goals. Several megacities (over 10 million people) have been created in China during the last decade due to accelerated urbanization. However, as the country experiencing the highest level of LULCC due to urbanization, China faces the challenge of maintaining economic development without sacrificing productive land for food security (Bai, Chen, & Shi, 2011). These facts reveal the future global challenges of maintaining the balance between human needs and limited natural resources.

Foley et al. (2005) anticipated the key challenges in human–environment land systems as

> "… the challenge of managing trade-offs between immediate human needs and maintaining the capacity of the biosphere to provide goods and services in the long term" (Foley et al., 2005, p.570).

Globalization has accelerated the distance drivers of land change in many parts of the world. Meyfroidt, Lambin, Erb, and Hertel (2013) demonstrated the effect of the following distance drivers of land change: unexpected land-use policy changes, environmental impacts and rapid socio-economic changes as the prominent characteristics experienced in these geographies. The interconnections created between countries or regions have become the new research agenda for land-use researchers when exploring distance drivers and their effects under the theme of "teleconnections" in a global context. A multi-region input–output analysis by Y. Yu, Feng, and Hubacek (2013) illustrates the off-country land-use of developed nations and regions in percentages as follows: the United States (US) 33%, European Union (EU) 50% and Japan 95%, while Latin American countries use a large portion of their crop land—Brazil 47%, Argentina 88%—for EU export markets. Moreover, the analysis shows the effects of increasing resource demand in China and India due to rapid economic growth, with these effects being on land-use in Africa, Russia and Latin American countries. On the other hand, excessive local agricultural production in peri-urban regions provides services elsewhere to support the increasing demand for food (changing dietary patterns and contemporary markets with growing populations) within countries/cities that have limited land and natural resources to fulfil rising needs, as well as issues with climatic conditions. Australian agricultural land provides products to export markets valued at over $4.5 billion (e.g. live cattle and sheep exports from Australia to Arabic nations and developing countries such as China, Pakistan and Indonesia; and Australian wheat exports providing products to markets in Indonesia, the Philippines and South Korea where dietary patterns are rapidly changing from rice to wheat) (ABARES, 2018; Mewett, 2013). These facts show the importance of integrating the distinct land connection with local land-use research to identify external drivers and the effects of land-use consequences in a local context. The concept of "tele-coupling" emerged as a commonly agreed framework that land-use researchers can use to improve knowledge of complex human-coupled land systems.

J. Liu et al. (2013) defined the tele-coupling concept as

> "... a logical extension of research on coupled human and natural systems, in which interactions occur within particular geographic locations" (J. Liu et al., 2013, p.1).

The investigative study by J. Liu (2014), using a tele-coupling framework for China forest-cover recovery and its effects on forest sustainability in China and forest product-importing countries, highlighted the importance in regional land-use research of using distant socio-economic and environmental changes when exploring land-use changes which are unable to be explained with strictly local considerations. The urban teleconnection concept has advantages in bridging the causes of urbanization and the impact of land-use changes by considering the land from the city centre to the rural hinterland as a single land system (Burak Güneralp, Seto, & Ramachandran, 2013). The economic connections between urban and non-urban areas also offer insights ranging from local to regional through to global economic processes (Hayter, Barnes, & Bradshaw, 2003). Seto, Reenberg, et al. (2012) proposed a process-based conceptual framework for capturing teleconnections in land-use change studies, particularly in areas subject to urbanization. This demonstrates the potential of the teleconnection application for exploring new urban area formation, such as peri-urbanizing, with a focus on surrounding areas and regional city connections

3. URBAN SPRAWL AND PERI-URBANIZATION

The term "urban sprawl" is extensively used by researchers and land administrators to describe major land-transformation processes and their consequences on peri-urban landscapes. Urban sprawl theory has a long history since its origins in the 1920s in economically advanced countries in that era (the US and European countries). It is also identified as "semi-suburbia" and "ribbon developments", representing landscape changes into urban form that occurred mainly along transport corridors (Bruegmann, 2001). After the Second World War, the term "urban sprawl" was widely used in European countries—mainly the German-speaking countries—to describe urban expansion due to industrialisation in and around the cities (Jaeger, Bertiller, Schwick, & Kienast, 2010). Mills (1981) identified urban sprawl as the lack of continuity in urban expansion. This was further confirmed by Peiser (1989) who demonstrated that low-density discontinuous expansions can significantly accelerate under the influence of larger utility, infrastructure and municipal land development projects occurring on city fringes.

Urban sprawl has often been described as an extension of the fringes or as urban settlement scattering over rural landscapes (Harvey & Clark, 1965). In a study on urban expansion, Gottmann (1957) identified the form of sprawl as fast-growing suburban areas closer to mega town centres, demonstrating the leap-frogging effect of sprawl due to increasing demand for land. Gottmann (1966) stated that most geographers in this era were focused on their areas of interest and on projects that created a lack of understanding of the sociological aspects associated with urban sprawl. The definitions of urban sprawl are often blurry and highly contingent on the area of research, viewpoints and associated geographies (Harvey & Clark, 1965). The existing definitions used for "urban sprawl" differ to a great extent based on the area of research interest, thus conveying contradictory interpretations. Consequently, it is difficult to agree on a consistent interpretation to compare case studies from different regions (Jaeger et al., 2010). This is further confirmed by Schneider and Woodcock (2008) who provided spatial evidence of urban growth in 25 cities around the world and indicated that "sprawl" is a relative concept that could vary in different geographies.

In a systematic review of urban sprawl definitions, Jaeger et al. (2010) separated the causes and consequences which were entangled in many definitions, resulting in a lack of clarity. The study identified the *causes*: unsystematic development; aimless and disorganized growth; demand for green landscapes; additional residences; and low-priced land parcels, while

identifying the *consequences*: degradation of landscape quality; loss of agricultural land and ecosystem services; loss of open green space and recreational areas; increase in number of commuters; and increase in spatial and functional separation in landscapes (Jaeger et al., 2010). Based on 50 years (1950–2000) of land-change data in the US, D. G. Brown, Johnson, Loveland, and Theobald (2005) reported that low-density outer-city residential developments drive the sprawl to city fringes and rural landscapes. Furthermore, Hasse and Lathrop (2003) proposed that the key land resource impact indicators of urban sprawl are: increasing urban density; loss of farmland, wetland and forest habitat; and increase in impervious cover. However, Chinese case studies demonstrate that the existing urban sprawl theories are not adequate to explain the contemporary urban sprawl patterns in China that are occurring due to larger land reforms—micro-level urban centres in "development zones" and temporary migrant settlements in "semi-urbanized villages" (F. F. Deng & Huang, 2004; X. J. Yu & Ng, 2007). In addition, Tian, Ge, and Li (2017) show that the urban sprawl trends in China are occurring due to "State-led" development processes, international direct investments for manufacturing industries and the oversupply of land for commercial industries by local municipalities, with these factors driving the sprawl to peri-urban and rural areas.

"Urban sprawl" is identified as a major land-use change practice that is associated with significant social and environmental costs, while presenting challenges for land-use planning on city fringes (Hasse & Lathrop, 2003; JunJie Wu, 2008). Bruegmann (2001) identified the major concerns of urban sprawl on city fringes as being environmental, social, aesthetic and equity issues. Wei and Ewing (2018) identified urban sprawl as a significant characteristic of contemporary urbanization or urban development processes. Many researchers (Gimblett, Daniel, Cherry, & Meitner, 2001; Ligtenberg, Bregt, & Van Lammeren, 2001; Mancebo, 2008; Rusk, 1993) have identified urban sprawl as a complex process involving the interplay of driving forces, namely, socio-economic, physical and political influences and their interactions. Land-use research has identified the fundamental forces which drive urban sprawl into nearby landscapes. Brueckner and Fansler (1983) indicated that urban sprawl is mainly driven by existing market forces rather than by economic symptoms. Furthermore, it was confirmed by Cuadrado-Ciuraneta, Durà-Guimerà, and Salvati (2017) that, in the last three decades, the diffused urban sprawl that occurred in European cities was due to speculation in the market, over net population growth. Batty (2009) described that, in addition to natural and physical factors, urban sprawl is driven by the historical reasoning of "historical accidents" associated with city geography. Brueckner and Helsley (2011) demonstrated that economic factors (i.e. urban land market failures) are the key force for urban sprawl with this intensified by inefficient spatial planning in urban areas leading to excessive peri-urban development. In a US-based study, Brueckner (2000) reported that the key drivers underlying urban sprawl are rising economies, population growth and the declining commuting cost on city fringes. However, the urban economy is central to these drivers on city fringes. The above points demonstrate the significant contribution of urban economies (through market forces) to driving urban sprawl into nearby landscapes, while influencing land-transition processes by the intensity and dynamics of socio-physical and land administration.

The term "peri-urban" has been defined broadly by multi-disciplinary researchers worldwide, in accordance with the understanding and knowledge developed in different geographic areas—by case studies—(Wandl & Magoni, 2017). The term "peri-urban" is commonly understood to mean the interface between urban and rural landscapes that is regarded as the land transitional zone due to human land-use change activities (Brook & Dávila, 2000; Michael Buxton & Choy, 2007; Douglas, 2006). Hedblom, Andersson, and Borgström (2017) have suggested the importance of specifying a specific population density or spatial distance to built-up areas to identify the peri-urban landscape by its functionalities. However,

the explorative reviews by Willis (2007) on peri-urban definitions demonstrate that it is impossible to have a singular or spatial definition for the term "peri-urban" in different geographic areas worldwide. This point was further confirmed by Amirinejad, Donehue, and Baker (2018) who demonstrated the ambiguity of the peri-urban interface due to the presence of diverse land-change drivers and the collective form of its expression in different cities worldwide. Simon (2008) provided substantial evidence that presented structurally and functionally different peri-urban areas in the world's regional cities, namely, in North and Latin America, Europe, Asia and Oceania. In an Australian study, Burnley and Murphy (1995) identified peri-urban areas as areas on the edge of cities that structurally and functionally consolidate urban expansion. However, the current study's author identified the term "peri-urban" as meaning landscapes that significantly differ (physically and functionally) to the urban built-up landscape or the rural agricultural landscape, in this study, referring to the context of Australian urban to rural continuums.

In many attempts and from different viewpoints, researchers have articulated peri-urban land-use characteristics and land-transitional progressions on city fringes. The key point is that peri-urban areas are the fastest-growing areas in the world's regions (Nelson et al., 1990; Davis et al., 1994; Low Choy et al., 2007; Brown et al., 2005). In Australian case studies, (M Buxton et al., 2011; Michael Buxton & Choy, 2007) demonstrated the effects of urbanizing processes occurring in peri-urban zones (peri-urbanization), such as closer land subdivisions, land fragmentation, frequent land-use changes and the mix of urban–rural land-use practices and functions. McGranahan, Satterthwaite, and Tacoli (2004) further demonstrated that spatial features associated with these land transitions are characterized by high land-use intensities, settlement pattern variations and land fragmentation. This leads to peri-urban landscapes with their highly spatially heterogeneous land-uses (Irwin & Bockstael, 2007; Jat, Choudhary, & Saxena, 2017). Willis (2007) listed the following land transition characteristics: fast-growing built form, land-use change, land administrative overlaps and growing population, as being significant in peri-urban areas. Low Choy, Sutherland, Gleeson, Sipe, and Dodson (2008) demonstrated that peri-urbanization is mainly occurring in the proximity of rural town centres through the sprawling of urbanizing processes into surrounding rural areas.

In regions throughout the world, cities may be surrounded by prime agricultural land, protected plantations, hilly forest areas, conservation areas and valuable wetlands, as well as by ecosystem services supporting urban inhabitants. Allen (2003) highlighted that peri-urban landscapes do not represent the attributes of either urban or rural areas. McGranahan et al. (2004) confirmed this statement by characterising peri-urban zones as areas that are significantly environmentally unstable compared to urban or rural landscapes. In a global assessment of urban and peri-urban agricultural land, Thebo, Drechsel, and Lambin (2014) reported that, of all agricultural land in the world's regions, 60% of irrigated land and 35% of rain-fed agricultural land are located within the 20 km buffer to urban areas, thus providing evidence of the demand for water in peri-urban agricultural practices worldwide.

4. IMPACTS ON THE ECOSYSTEM

Contemporary urbanization has accelerated the human influence on the ecology in the biosphere (Bian, Wang, Wang, Yu, & Qian, 2018; Ellis, 2011; Folke et al., 2011). B Güneralp and Seto (2013) forecast that, by 2030, global urbanization would make significant impacts on protected areas, particularly in the regions of China and South America. Ecological research on urbanizing areas has confirmed that human influence on changes to natural environments includes the adverse impact of ecosystem services and functions (Elmqvist et al., 2013a; Ramalho & Hobbs, 2012; Jianguo Wu, 2014). The land-use research community has identified the advantage of using LSS for ecosystem service quantification, valuation and management,

exploring the connection between land-use change and ecosystem service alterations in the context of supply and usage (Crossman, Bryan, de Groot, Lin, & Minang, 2013; X. Deng, Li, & Gibson, 2016; D. Robinson, Brown, & Currie, 2009; Serna-Chavez et al., 2014). Recent urban ecological studies have focused on the supply and demand of ecosystem services in the analysis of urban sustainability (Baró, Haase, Gómez-Baggethun, & Frantzeskaki, 2015; Kain, Larondelle, Haase, & Kaczorowska, 2016; Larondelle & Lauf, 2016; Lauf, Haase, & Kleinschmit, 2014). Moreover, researchers have explored the socio-economic dimensions of the human influence on the ecosystem services of human-dominant land systems. However, as Mononen et al. (2016) demonstrated in existing land management policies, ecosystem service information gaps still exist due to the lack of concrete definitions and classifications.

The infiltration of urban sprawl onto nearby rural landscapes—peri-urban landscapes—has created the dynamic interface of human–environment interactions. Rolf, Peters, Lenz, and Pauleit (2017) demonstrated the peri-urban farmland's contribution to developing the urban green infrastructure in three German cities through the maintenance of the essential habitat and functional connectivity in ecological systems. Recent urban ecological studies have focused on deteriorating ecosystem services in urban and peri-urban landscapes (Larondelle & Lauf, 2016; Zhu, Reid, Meharg, Banwart, & Fu, 2017), which are often surrounded by agro-ecosystems.

Jianguo Wu (2013) described the landscape as

> "… places where people live and work, and where ecosystems reside and provide services to people" (Jianguo Wu, 2013, p.1019).

Ecosystem services in agro-ecosystems often receive less attention among land management practitioners (Sandhu, Crossman, & Smith, 2012). These services in urban fringe farmland have substantial benefits for both urban and peri-urban inhabitants, fulfilling their rising demands for food and other natural resources while achieving the goals of human well-being. In peri-urban areas—which are dynamic landscapes—ecosystem services make a significant contribution when maintaining peri-urban landscape sustainability (Jianguo Wu, 2013) while protecting and restoring urban ecology (Verburg et al., 2015). A comprehensive analysis of ecosystem properties by Matson, Parton, Power, and Swift (1997) shows the extensive environmental consequences that could be experienced under agricultural land intensification. As well as socio-cultural changes, agricultural land-use intensification on urban fringes is often the cause for weakened ecosystem services through its contribution to changes in the quality of water, air and soil. The land-use research literature has not adequately addressed peri-urban agricultural land-use intensification and its impacts on land-use sustainability in these land transitional zones (Sonter, Barrett, Moran, & Soares-Filho, 2015).

5. SUSTAINABILITY ON CITY FRINGES

Many land-use studies have used the term "sustainability" when expressing the idea of achieving a balance between human expectations and the environmental system by offering thresholds (X. Deng et al., 2016; Turner II, 2016; Verburg et al., 2015). For the UN-affiliated International Institute for Sustainable Development (IISD), Brundtland (1987) defined sustainable development as:

> "… development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p.41).

A report written by Kaphengst (2014) titled "Towards a Definition of Global Sustainable Land Use" identified the unclear definitions of "sustainable land use" in the literature. Furthermore, the report identified the theoretical and conceptual implications associated with the IISD definition of "land governance", while suggesting a new definition for sustainable land-use as follows.

A global sustainable land use serves the needs (for food, energy, housing, recreation etc.) of all human beings living on earth today and in the future, respecting the boundaries and the resilience of ecological systems (Kaphengst, 2014, p.12).

Zheng, Shen, and Wang (2014) showed the complexity associated with sustainable development in the urban development literature, demonstrating the frequently changing definitions. Moreover, Berke and Conroy (2000) defined sustainable development as a dynamic process.

> Sustainable development is a dynamic process in which communities anticipate and accommodate the needs of current and future generations in ways that reproduce and balance local social, economic, and ecological systems, and link local actions to global concerns(Berke & Conroy, 2000, p.23).

These points demonstrate the lack of clarity of the term "sustainable development" in the land-change literature as it fluctuates between different geographies amid the existence of varying socio-cultural and environmental conditions. The author recognizes the term "sustainable land use" as meaning the adaptation of the use of land to achieve an optimum balance between human needs and natural environmental services within a certain time, while changing the land-use to fulfil society's rising demands.

The land-use literature demonstrates that peri-urban land transitions are becoming a popular theme among land-change researchers. This is evident in the case studies produced during the last few years (since 2014) on various cities around the world: France (Duvernoy, Zambon, Sateriano, & Salvati, 2018); the USA (M. Brown & McCarty, 2018); Canada (Akimowicz, Cummings, & Landman, 2016); China (Shih, 2017); Vietnam (Nguyen, van Westen, & Zoomers, 2017); Sweden (Hedblom et al., 2017); Indonesia (Winarso, Hudalah, & Firman, 2015); Peru (Haller, 2014); Ghana (Appiah, Bugri, Forkuor, & Boateng, 2014); and Australia (Z. Liu & Robinson, 2016). Peri-urban land-transition studies have focused on the various aspects of land change and its impacts: land-use planning and urban development; urban ecology; urban sustainability; socio-economic changes; agricultural landscapes; and population dynamics, while representing cities from different geographies. These studies show the necessity of improving knowledge regarding peri-urban land transitions, following recent contemporary urbanization trends.

Peri-urban regions are characterized by socio-economic dynamics and ecosystem service depletion, while being constantly subject to land acquisitions and tenure changes (Seto, Reenberg, et al., 2012). Furthermore, peri-urban typology features a mixture of urban and rural land-use features with continuous land changes, conflicts of targets and higher levels of land-use heterogeneity (Low Choy et al., 2008). Peri-urbanization has a constant connection with urban sprawl as it always occurs under urban drivers (Hersperger & Bürgi, 2009). Galli, Lardon, Marraccini, and Bonari (2010) showed the different aspects of peri-urbanization phenomena demonstrating the opposite views in the literature: one view identifies peri-urbanization as an unsustainable process breaking the connection between city and rural areas, while the other identifies it as a new form of sustainable development that creates new opportunities with positive land transformations.

Peri-urban land-change research has identified the complexity associated with peri-urban land systems that are continuously subject to changes with insights from socio-economic policies, ecosystem services and institutional policies on land governance (Douglas, 2006; Ravetz, Fertner, & Nielsen, 2013; Seto, Reenberg, et al., 2012; Simon, 2008). Rauws and De Roo (2011) described the non-linear characteristics of complex peri-urban land transitions and their dynamics with these often not being part of the radar of land-use planners. The LSS literature has identified the importance of considering urban, peri-urban and rural areas as a common land system consisting of mutual connections, to explore land transitional processes for sustainable solutions (Seto & Reenberg, 2014). The above points demonstrate the advances

made by LSS in peri-urban land transitions. However, opportunities still exist for improvements in knowledge in the areas of scale dependency, autonomous processes and the robustness of land systems.

6. URBAN ECONOMIC EFFECTS ON PERI-URBAN AGRICULTURAL LAND FUNCTIONS

As a result of the economic shift from agriculture to industry, many cities worldwide have lost farmland in peri-urban areas (del Mar López, Aide, & Thomlinson, 2001), with these land-use transition processes rapidly continuing with economic development in urbanizing cities. International trade, national border opening and cross-border influences have triggered the demand for land transformation (Gardiner & Le Goulven, 2001), particularly transformation that brings about agricultural land-use functional changes or loss on city fringes. (JunJie Wu, 2008) demonstrated that urban sprawl affects agricultural economies on the fringes by reducing the land area—or critical mass—below the minimum required for agricultural economic survival, which ultimately leads to the collapse of farming practices and services supporting agriculture in these urban fringe areas.

The functional arrangements of the peri-urban agricultural land-use of cities vary between developed and developing nations. Nugent (2000) showed the significant difference between peri-urban agricultural practices in developing countries that engaged with poor urban dwellers with less intensified (using less fertiliser/energy) agricultural practices and those of peri-urban areas of wealthy cities in developed nations that consisted of large-scale commercial/multi-functional farming practices. The countries of the Global North have identified the importance of preserving the peri-urban agricultural practices that contribute to the local economy and carry non-market benefits for urban inhabitants' quality of life. Developing Asian nations, such as China and India, are experiencing significant structural changes in peri-urban agricultural land functions to fulfil the demand for developing megacities and medium-sized cities to satisfy the increasing population and expanding economies (Hussain & Hanisch, 2013; Shih, 2017; Tian et al., 2017). Moreover, direct industrial investments in the densely populated cities in Asia (i.e. Manila, Dhaka, Chennai and Jakarta) demonstrate significant agricultural land functional changes due to the rapid change of socio-economic conditions. However, urban development and economic research in the literature have paid less attention to peri-urban agricultural functions (Bezemer & Headey, 2008).

Urban/rural research in the current literature provides limited knowledge on the economic impact on peri-urban agricultural practices that depend on the following economic variables: income, annual output and employment (Nugent, 2000) that combine as an economic force, changing agricultural land functions in peri-urban landscapes. Researchers have found, in the cities experiencing urban sprawl, that this is due to economic expansion, and significant land demand generated for housing, infrastructure and transport in and around the peri-urban and nearby rural landscapes (Greene & Stager, 2001; Livanis, Moss, Breneman, & Nehring, 2006). The increasing demand for land on city fringes creates adverse effects for peri-urban agricultural land-use functions by increasing the competition for limited farmland. In a study exploring peri-urban agricultural land values, Shi, Phipps, and Colyer (1997) identified the key economic factors of nearby urban economic demand and farm income as the determinants of agricultural land value that had a significant impact on agricultural land functions in these landscapes. Furthermore, in a study on market impacts on land-use change, Sun et al. (2014) demonstrated that peri-urban farmland can prevent urban sprawl as long as the opportunity cost of converting farmland to housing is higher than urban dwellers' buying power. The increasing land demand for infrastructure and transportation projects leads to the acquisition of peri-urban

farmland to facilitate the creation or expansion of services to maintain economic demand while challenging urban land-use planning in the growing cities (Elhadary, Samat, & Obeng-Odoom, 2013; Heimlich & Anderson, 2001; Mougeot, 2000). These points demonstrate the effects of urban economic expansion on functional changes in peri-urban agricultural land-use that are carried through on different channels.

Agricultural land intensification has become a global trend in the contemporary world (van Vliet, de Groot, Rietveld, & Verburg, 2015; Wandl & Magoni, 2017) and is prominent in peri-urban areas. Farmers in peri-urban areas often receive higher crop prices due to urban centres' rising demand for crops for local consumption and export markets. Due to contemporary technological advancements, farmland has become competitive (Arsenault, Nolan, Schoney, & Gilchrist, 2012). To satisfy the increasing economic demand for agricultural commodities, farmland intensification is a common agricultural functional change that occurs in peri-urban landscapes by increasing the competition for farmland. Intensified agricultural practices require low-cost labour, new technology and irrigated water to maximize economic returns from the limited land of peri-urban farms. In developed nations, low-cost labour is commonly provided by poorer residents on city fringes. Farmers must, however, compete with non-agricultural sectors for labour on the fringes. Part-time elderly retirees also provide a significant labour supply for farming practices on city fringes which is not accounted for in peri-urban agricultural economics (Nugent, 1999). This situation differs in developing nations, due to non-agricultural economic opportunities in cities and the lack of labour, both of which increase the level of farmland abandonment and its conversion to housing or infrastructure development to satisfy the rising land demands of growing populations.

Land-use planning, in parallel with economic behaviours, plays a significant role in peri-urban areas by identifying the development and preservation zones needed to satisfy the demand for land. This land-use zoning often has a significant effect on peri-urban agricultural land functional changes, with agricultural land in development zones often characterized by land-use changes—land subdivisions, fragmentation and intensification—while farmland in preservation zones is characterized by long-term stable agricultural practices on larger land parcels on city fringes. Land-use planners are also often concerned with the adverse effects of agricultural land functional changes on urban inhabitants due to land intensification, fragmentation and the extinction of green landscapes (Huang, Wang, & Budd, 2009). Therefore, land-use regulations often focus on land subdivisions and the increase in waste water emissions associated with land intensification practices. On the other hand, peri-urban agricultural businesses provide employment opportunities for rural communities (Allen, 2003) with this rarely considered by planners with urban priorities. However, (James & O'Neill, 2016) argued that urban planners either neglect or underestimate the peri-urban agricultural contribution for the local economy and sustainability of cities, both in Australia and overseas.

Researchers pay special attention to peri-urban agriculture as it often operates under the influence of the urban sprawl of cities surrounded by farmlands. In land-use research, the limited literature on peri-urban agricultural practices has focused on food security (Thebo et al., 2014; Tsuchiya, Hara, & Thaitakoo, 2015); agricultural land loss due to urban expansion (Elhadary et al., 2013; Pham, Pham, Tong, Nguyen, & Pham, 2014; Pribadi & Pauleit, 2015, 2016); drivers of farmland change (Serra, Saurí, & Salvati, 2017); ecosystem services in agricultural landscapes (Lee, Ahern, & Yeh, 2015; Thapa & Murayama, 2008); land-use multi-functionality (Ives & Kendal, 2013; Zasada, 2011); and farmers' socio-economic aspects (Hussain & Hanisch, 2013; JunJie Wu, 2008). These multi-directional themes represent the complexity associated with the occurrence of agricultural land transition processes. Land-use research also identifies the conversion of agricultural land into an urban form as a key component of the peri-urbanization process (Fragkias, Marcotullio, & Karen C.; Simon, 2012), including the common status of agricultural land intensification, fragmentation and, ultimately,

transformation into an urban form (Seto, Reenberg, et al., 2012). However, this sequence is not followed all the time on city fringes owing to the complexity arising from socio-economic and environmental system dynamics. Land system science (LSS) has developed, but has limited knowledge on, peri-urban agricultural land transition processes, such as: what situations lead to the occurrence of these transitions; where they are more likely to occur; the influences on peri-urban farmers' land-use decisions; and the scale, rate and space of transitions occurring in peri-urban land systems.

7. FUTURE RESEARCH CHALLENGES ON PERI-URBAN LAND TRANSITION

The above broader topic areas of land-use literature demonstrate the advantage of having a land system science lens in land change research for understanding the peri-urban land transition phenomenon, along with the contemporary urbanizing trends.

Out of the many challenges present, understanding the economic theory behind changing the land-use functions due to various form of urban demands, is a major area in need of focus in future peri-urban land change research. It is important for deepen existing knowledge on peri-urban agricultural land transition phenomena while contributing towards land-use planning at the city fringes. Deepening the knowledge on economic drivers of land-use change in macro-scale (cross-border trade, inter-dependencies, direct investments and economic interactions among different cities in different nations), is also another area that pursue knowledge improvements through interdisciplinary research.

Addressing the ambiguities in defining "urban" and "peri-urban" and the complexities associated with the peri-urban land functions due to urbanization is another area in need of focus by the land-use research community while differentiating between the causes and consequences of land-use change particularly at the peri-urban landscapes. The literature shows a significant need for identifying the peri-urban characteristics in different global regions while exploring emergent peri-urban land transition processes and patterns within the areas.

Agreeing to an expected level of land-use sustainability in peri-urban areas is also a prominent challenge emerging through the literature review based on case studies represented from different geographies. A scientific debate on agreeing for an optimum balance between community expectations and the natural environment services of the area within a certain time period provides research directions to the land change scientific community to explore effective land management practices at the city fringes. Overall, the future of peri-urban land-use research faces the challenge of maintaining balance between urban economic prosperity and sustainable land management at the urban fringe land systems.

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