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How Do Global Demographic and Spatial Changes Interact with Agrobiodiversity?

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Abstract

This chapter seeks to identify the linkages between agrobiodiversity and global demographic and spatial changes. Using an interdisciplinary approach, it reviews research models and empirical studies that link demographic and spatial changes to socioecological interactions involving agrobiodiversity at different spatial and temporal scales. Concepts are employed from the frameworks of geographic synthesis, socioecological systems, global change science, coupled human–natural systems, agroenvironmental history, development studies, and political ecology. Seven globally predominant linkages are identified: demographic change and population effects; urbanization and peri-urban expansion; migration including refugee movements; agricultural trade, markets, and food systems; spatial and land-use planning, zoning, and territorialization; food security, food sovereignty, seed movements, sustainable intensification, ecological intensification, and agroecology; and ongoing historical, cultural, and social network influences. Conditions of the major drivers bear complex relations to agrobiodiversity that range from loss and genetic erosion to continuing utilization, the emergence of expanded or innovative new uses, and conservation contributing to the sustainability of food systems. Linking the causal drivers of change to the range of possible outcomes depends on assessing the context-dependent roles of intervening and intermediate-level factors rather than ironclad mechanisms. Several intermediate-level factors are evaluated for each topic and recommendations are offered for future policy-relevant scientific research.

Introduction: Defining Agrobiodiversity Interactions with Demographic Change and Spatial Integration

To understand current fluctuations in agrobiodiversity and equip us to meet future challenges, demographic and spatial changes require thorough

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examination. As primary drivers of agrobiodiversity change, both involve multiscale processes at various levels (from global to local). Thus, our overall framing must extend beyond the biological factors that have traditionally defined the core concept of agricultural biodiversity. The consideration of current population movements, both economic and refugee, and urbanization—whether rural to urban or displaced people increasingly concentrated in refugee camps—illuminates key geographic and socioecological factors that transcend classic disciplinary boundaries. By focusing on the interdisciplinary characteristics of demographic and spatial change, our goal is to examine the complex socioecological interactions involving agrobiodiversity at different spatial and temporal scales. We use the term "agrobiodiversity," which is already in common usage (see Chapter 1), to reflect this framing. This expanded conceptual framing is essential to delineating research directions in policy-relevant science and scholarship on agrobiodiversity amid dynamic changes (Bioversity Intl. 2017).

Our chapter extends well beyond conventional single-factor explanations by analyzing demographic and spatial changes in relation to population factors, political and economic forces, and production and consumption trends. The processes of demographic and spatial change include human population growth and decline, urbanization, migration (economic and political including populations in refugee or migrant camps), and the spatial integration of agricultural commodities and food systems across national boundaries and into international and global systems through institutions and policies as well as the everyday actions of migrants on the move. Much demographic and spatial change is closely related to global-scale drivers and the kinds of integration associated with globalization. Our referring to "global demographic and spatial change" also acknowledges that these processes often occur at the intermediate and local level.

We discuss the relationship between agrobiodiversity and sustainability, sustainable development, sustainable intensification, and ecological intensification in agriculture, food security, and food sovereignty as well as the regulation of food labeling. Each discussion includes the spatial and scale dimensions of these efforts; for a discussion of related agrobiodiversity interactions with plant breeding and industry, see Chapter 6. In addition, agrobiodiversity's interaction with demographic and spatial changes draws attention to the powerful influence still exerted by the past. Indeed, we highlight the relevance of historical precedents as well as specific past agrobiodiversity interactions, like the diverse food traditions enriched through pre- and early European trade across the Indian Ocean discussed below.

Agricultural biodiversity refers strictly to the biodiversity of genetic populations, cultivars and breeds, and species of both domesticated organisms and their wild relatives as well as agroecosystems (FAO 1999a). Various expanded versions of this definition incorporate knowledge systems, landscapes, and global environmental and socioeconomic changes (CBD 2000; Jackson et al.

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2007; Zimmerer 2010). Recent research suggests bringing additional dynamic sociocultural and spatial processes into the broader conceptual framework of agrobiodiversity (Rangan et al. 2015; Zimmerer and de Haan 2017). In particular, we note that dynamic sociocultural and economic drivers, potentially resilient socioecological systems, and broad historical influences are also integral to agrobiodiversity. These additional dimensions have gained new importance in the context of current demographic change and spatial integration (Carney 1991, 2001; Pautasso et al. 2013; Zimmerer 2003a).

Our discussion focuses on the question: How do demographic and spatial changes interact with agrobiodiversity? We emphasize the predominant causality of past and current research, namely social and environmental impacts on agrobiodiversity. At the same time, we also recognize the potential importance of the converse: agrobiodiversity can and does affect demographic and spatial changes, although to date there remains little research on these less common impacts. Mindful of the coupling of socioecological interactions in complex environmental systems, we are keen to point out that agrobiodiversity itself can play an active and dynamic role in certain demographic and spatial changes, rather than the often assumed notion that it is a passive component in larger human systems and thus is strictly an outcome of socioenvironmental drivers. Agrobiodiversity's anticipated, significant influence on demographic and spatial changes, while nascent in research scholarship, leads us to highlight its importance to future research.

We discuss seven types of agrobiodiversity dynamics linked to demographic and spatial changes:

- Demographic change and population interactions
- Urbanization and peri-urban expansion
- Migration
- Integration of agricultural trade, seed and product markets, and food systems
- Spatial and land-use planning, zoning, territorialization, and social movements
- Food security, food sovereignty, sustainable intensification, and ecological intensification
- Historical, cultural, and social network considerations

For each dynamic, we survey current agrobiodiversity research and highlight potential directions for future research.

Demographic Change and Population Interactions

By demographic change we mean forces that range from global population growth rates to the expansion of conurbations into megacities and more recently, the accelerating growth of medium-size cities. This has also incurred

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population decline and transitions to part-time agricultural employment in rural areas of both the Global North and South, specifically in environments that are marginally productive. Simple causal relations are not evident between these demographic changes and environmental resource and management responses, of which agrobiodiversity is one factor. Even the agrobiodiversity associated with extensive forms of land use, such as swidden farming, has a complex relationship with population growth and decline (Blanco et al. 2013; Ironside 2013). Brookfield (2001) and others (Brush 2004; Zimmerer 1991a, 1997, 2010, 2014) have argued convincingly that these demographic processes are entwined with agrobiodiversity change in the fabric of large socioeconomic forces. Our perspective on this absence of simple demographic causation in global agrobiodiversity change also echoes the influence of prominent, wide-ranging treatises on environmental sustainability and degradation (Boyd and Slaymaker 2000; Fischer-Kowalski et al. 2014; Tiffen et al. 1994).

The majority of farmers cultivating and consuming agrobiodiversity belong to the group of 2.2 billion smallholders worldwide while other, distinct socio-economic groups—each with characteristic levels of agrobiodiversity—also play significant roles in the sustainability of this resource (Figure 8.1). The group comprised of smallholders consists of a highly heterogeneous group that encompasses both poorer segments, including much of the world's food-insecure population (HLPE 2017; IPES-Food 2017; Zimmerer et al. 2018), and slightly better-off populations as gauged by capital and resource levels (the two groups on the left side of the x-axis in Figure 8.1; see also Chapter 6). Our treatment of global populations important to agrobiodiversity also identifies two other broadly defined groups: medium-size farms and large farm enterprises (the two groups on the right side of the x-axis in Figure 8.1). Each of the four groups is treated as a general category or archetype per methodological advances in the socioecological sciences (Bennett et al. 2005; Janssen et al. 2006; Oberlack et al. 2016; Sietz et al. 2017).

As shown, the food growers corresponding to the slightly better-off smallholder population—the sociocultural and demographic groups comprised of somewhat more well-to-do peasants, Indigenous or traditional peoples as well as neoagrarians and "back-to-the-landers"—generally produce and consume the highest levels of agrobiodiversity of any of the four main groups. Figure 8.1 illustrates that the poorer smallholder group, which includes many resource-scarce and food-insecure farmers, is by far the largest.

Demographic change is widespread among both the largest group of smallholders and the slightly better-off group. Large-scale socioeconomic processes, such as the increased shift of rural livelihoods in the Global South to part-time farming and land use, are significant drivers of that change. This shift is typically incompatible with agrobiodiversity because the agricultural emphasis becomes centered exclusively on cash-cropping monocultures. Similarly, this shift is frequently counter to the input needs of agrobiodiversity, such as the critical labor–time shortages that frequently undermine agrobiodiversity

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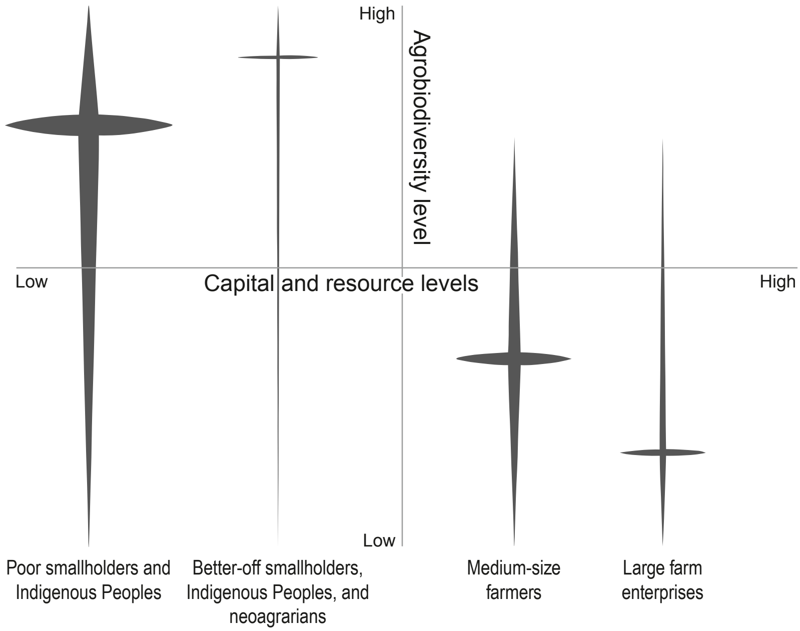

Figure 8.1 Global demographic groups based on resource-level archetypes (thickness represents relative demographic importance) and corresponding ranges (y-axis) and relative extents (filled area within each shape) of agrobiodiversity. Figure drafted by Sophie Najjar and used with permission.

production and consumption systems (Zimmerer 1991a, 2010; Zimmerer and Vanek 2016) as well as seed systems (Bellon 2004).

This shift of livelihoods to part-time farming can, however, potentially coincide with continued agrobiodiversity use when other conditions are present, like polycultures, mixed farming, adequate resource access, and institutional support (Zimmerer et al. 2018). Specific examples of this compatibility, and the conditions required, are addressed below. Still, even scenarios that are favorable for agrobiodiversity conservation as part of persistent land use, livelihood, and consumption strategies may prove inadequate amid global changes broader in scope, thus requiring additional external organizational and institutional support (Reenberg et al. 2013).

Demographic change often intersects with sociocultural and economic differences in the processes affecting agrobiodiversity. One of the most common examples involves the demographic dimensions of increasingly common migration and part-time farming, examined in detail below. In these circumstances, farm labor and knowledge is often gendered; women are likely to be most immediately involved with agrobiodiversity growing and food preparation (Chambers and Momsen 2007). Other social differences, such as race,

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ethnic group, and age, may also become actively incorporated into demographic shifts such as migration (Zimmerer 2014).

Urbanization and Peri-Urban Expansion

Recent, rapid urbanization throughout the world, especially in tropical regions, is the result of powerful global drivers and their effect on the environment. This is causally linked to changes in food systems and agriculture that impact the growers of agrobiodiversity and consumers' access to it via food markets (Bioversity Intl. 2017; HLPE 2017; IPES-Food 2017; Zimmerer 2010). Partial persistence of smallholder food and farming systems involving agrobiodiversity is possible in the expansive peri-urban contexts of the Global South (Ávila et al. 2017; Eakin et al. 2014; Lerner and Appendini 2011; Poot-Pool et al. 2015; Prain et al. 2010; Zimmerer 2013). Gardens, small fields, and informal spaces, such as river margins and rented or vacant land within urban areas, provide diverse opportunities for food production and continued use of agrobiodiversity. At the same time, many peri-urban agrobiodiversity growers are engaged in highly diversified livelihood strategies that depend principally on off-farm employment.

Ethnicity and socioeconomic interactions also influence the spatial dynamics of food production in urban contexts that incorporate agrobiodiversity. The encouragement of dedicating space to growing food varies widely from city to city, and support is typically partial at the most, making community, neighborhood, producer, and consumer groups vital. Approaches include urban and peri-urban farming in backyards, abandoned lots, community gardens, under power transmission lines, in traffic medians, and along sidewalk curbs as well as new designations like peri-urban agrarian parks (Pinna 2017; Pirro and Anguelovski 2017; Serra et al. 2017). Immigrant gardens are important sites of agrobiodiversity-growing in both private lots and in public spaces that are either informal or, in other cases, supported by city and municipal governments (Baker 2004; Imbruce 2007; Taylor and Lovell 2014).

Widespread local organic growing and direct producer-consumer arrangements, such as community-supported agriculture (also known as community-shared agriculture), as well as more restricted innovations like "seedy Saturdays," which may or may not support high agrobiodiversity, also have widespread potential. Such initiatives feature food that can be grown and consumed locally; it can be either marketed to consumers with high purchasing power or, in some cases, may be priced affordably.

Urbanization also reveals the potential of abbreviated food supply chains, innovative food marketing, and cultures that value local and artisanal food traditions. A good example of innovative marketing is Bioversity International's projects that promote diverse African leafy vegetables in Kenya and other high agrobiodiversity foodstuffs for their benefits to human nutrition and

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food security (Bioversity Intl. 2017; HLPE 2017; IPES-Food 2017). Research analysis of such initiatives needs to evaluate not only the shortness of the supply chain but also the impact of demand, and which markets are linked to agrobiodiversity.

This emphasis and the role of urban-based trends can also promote high agrobiodiversity foods and the consumption of diverse wild, gathered, and caught kinds of food (Aubry and Kebir 2013; Reyes-García et al. 2015). Research on urban food cultures needs also to consider the global marketing strategies of the industrial food sector and its massive domination of food supply and consumption trends to date (Cockrall-King 2012). These trends can seem to embrace agrobiodiversity, at least at first glance, while actually undermining it, as discussed below (see section on Agricultural Trade, Markets, and Food System Integration, which reviews findings on the global quinoa boom).

Even the current success of fresh food, farm-to-table or soil-to-plate retailing, the business and marketing boom for "healthy" products, and the innovations of celebrity chefs, restaurateurs, and television shows promoting experimentation with diverse foodways may unfold in unanticipated ways. On the one hand, the urban-based food movements involving consumers and chefs who embrace high agrobiodiversity foods, such as has occurred in Lima and in other urban areas of Peru, can lead to demand for more agrobiodiversity as part of the valorization of new eating experiences. The Slow Food movement, which is active across many countries, vividly illustrates these trends and how they suggest resistance against the homogeneity of food system integration.

On the other hand, the current interest in novel foods can reinforce existing categories of social difference, disadvantaging Indigenous Peoples' diets when some of their traditional foods (e.g., quinoa, açaí, amaranth, chia, maca, rooibos, goji berries) become a fad in the Global North because of presumed nutritional benefits. This can move crucial subsistence staples to urban areas or from one region of the world to another, negatively affecting the farming practices and diets of specific groups based on ethnicity, race, gender, or age (Skarbø 2015; Winkel et al. 2016).

To determine the impact of peri-urban and urban farming on agrobiodiversity requires also an assessment of whether the shortened food chains concentrate on producing a few specialized crops or incentivize diverse foods that contain high levels of nutritional diversity, agrobiodiversity, and agroecological functioning. Future research is needed that will measure the impact of new labor and environmental linkages on farms, in communities, and across the geographical networks that link producers to consumers (McMichael 2013; Shaver et al. 2015).

An example is the impact of urban "gastronomic booms" that encourage the demand for agrobiodiversity and that can potentially offer benefits to poorer growers (see Chapter 15). There is also evidence, however, that price premiums, to the extent they exist, are often captured by more well-to-do agriculturalists. Problems like malnutrition, massive dietary shifts among young people,

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and the entrenchment of socioeconomic drivers that remain disadvantageous to poorer growers persist (García 2013; Tobin et al. 2018). The demand derived from booms is generally short lived, triggering unsustainable value chain interactions and land use change.

Research on demographic changes and spatial integration associated with urbanization, and their significance to the balance of human populations and food systems is also needed. In particular, the worldwide growth of urbanization and the concomitant, increasing influence of urban on rural spaces (the so-called "urban in the rural") as well as the expansion of global, industrial food systems must be seen in relation to the role of smallholders. Within the heterogeneous group of 2.2 billion smallholders, more exist in the peri-urban and urban-in-the-rural contexts than those whose livelihoods can be characterized as remote rural (Zimmerer et al. 2015).

Migration and Movements of Refugees and Displaced Persons

The mobility of people on our planet has reached unprecedented levels. The United Nations reported that in 2015 the number of international migrants—persons living in a country other than where they were born—reached 244 million. This represented a 41% increase for the world as a whole compared to 2000 (UN 2016). Included in this estimate of mostly economic migration are more than 20 million refugees who were forced to relocate. Long-distance trade and economic migration has long been important, even prior to the period of European colonization (see below), but its scale has vastly increased in this century. Tens of millions of people now migrate across borders each year. The estimate of migration within countries is even larger. Furthermore, a new generation of temporal migrants, frequently part-time farmers moving back and forth between the countryside and cities, has emerged.

Significantly, many migrants from each of these groups are smallholder farmers who have traditionally (and disproportionately) relied on agrobiodiversity in their farm plots and gardens. Garden areas are especially important to migrants since they involve lesser amounts of land and field labor while containing moderately high levels of agrobiodiversity (Galluzzi et al. 2010). The capacity for innovation is great since even "traditional" home gardens have been proven to be impressively versatile when adjusting to changing circumstances (Trinh et al. 2003).

Migrants often maintain connections to seed networks through family members and extended households that remain in their "source areas" (Alexiades 2012), but sometimes migrant households lessen their levels of agrobiodiversity. Individual migrants can be viewed as diversifying the livelihood strategies of their source households by extending such linkages into the areas to which they move. This vast expansion of international migrants combines with local population movements that affect agrobiodiversity, like the common practice of

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a relocated spouse bringing seed from their former home to their new location in exogamous marriage. In special circumstances, the level of knowledge of migrants can even be higher than those from the "source areas" (Vanderbroek and Balick 2012). Migration also intersects deeply gendered processes, often contributing to the significant "feminization" of on-farm work activities that can include agrobiodiversity (Carney 1993; UN 2016; Zimmerer 2014).

While such strategies for livelihood diversity can negatively impact agrobiodiversity, under certain conditions, the levels of agrobiodiversity are maintained and agriculture may even be intensified (McCord et al. 2015). As illustrated in Figure 8.2, a household's access to land, water, and seed resources as well as specific demographic, socioeconomic, and political–economic factors are often the key conditions influencing agrobiodiversity outcomes in livelihood diversification contexts (Zimmerer and Vanek 2016). This illustration illuminates the many human–social and environmental dimensions that resource access encompasses (Ribot and Peluso 2003) along with multifactorial influences on agrobiodiversity outcomes. Determining the conditions of specific trajectories through empirical and predictive models is a crucial next step for research and policies guiding environmental sustainability (Gray 2009; Gray and Bilsborrow 2014).

Refugees' flight is forced, involuntary, and currently extensive in scope, and an important contrast and counterpart to the economic migration described above. Both forms of mobility are especially important to agrobiodiversity in current global contexts. The contemporary turmoil in Syria and Iraq has instigated an influx of refugees into Europe of epic proportions; over a million refugees have arrived in recent years. In sub-Saharan Africa, refugee camps are disproportionately made up of women and children who have fled conflicts

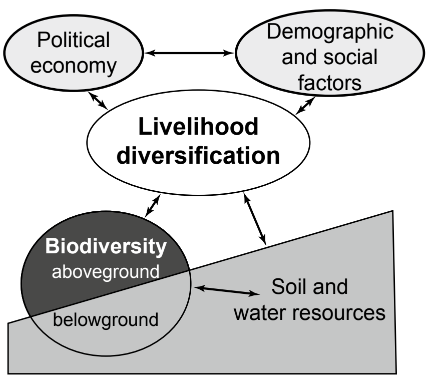

Figure 8.2 Conceptual diagram of the linkages between livelihood diversification and human–social factors as well as agrobiodiversity and related environmental factors. The lower arrow represents the pathway of impacts occurring via the linkages of belowground agrobiodiversity and natural resources, principally soil and water resources. Adapted from Zimmerer and Vanek (2016), an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license.

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and sought safety elsewhere in their country or in neighboring countries. The capability of regional food systems and food aid to feed these impoverished and uprooted people in concentrated settings is already stretched and worsening as years go by and families are still unable to return to their homeland (e.g., Somalis living in Kenyan camps, Rohinga refugees in Bangladesh and Malaysia, Myanmar's Karen people in Thailand). The necessity of feeding people through means other than food aid will grow as intractable conflicts turn such camps into quasi-permanent settlements.

The land surrounding refugee camps, many of which are located in rural areas of Africa, Southeast Asia, and the Middle East, could be providing food, given the number of camp inhabitants with little to do. In addition, such sites allow for the reassertion of cultural traditions that inform specific foodways. Growing the condiments and foods specific to their culture has always been a way for migrants to reestablish meaning and identity in exile (Carney and Rosomoff 2009). Among current refugees, the combinations of these cultural concerns and foodway practices together with the need for food security and health—and nutritional security in particular—has spurred a number of institutional initiatives worldwide that involve the diverse sourcing of seed for food plants and gardens among refugee populations. The 15th Garden, an initiative supporting seed availability and gardens in refugee camps in Syria, is an example that receives support from displaced Syrians and Europeans (Zimmerer 2017a).

The likelihood that refugees will remain in these areas for many years, indefinitely over generations, or will be resettled in cities, needs to be foremost in how we think about self-provisioning, agrobiodiversity, and resilience in the coming decades. Experts on projects in this domain underscore the complexity of agrobiodiversity interactions in refugee contexts. Paul Richards and colleagues point out the promise and applicability of agrobiodiversity to enhance food sovereignty among refugees and displaced persons worldwide and especially in several countries in Africa (Richards and Ruivenkamp 1997). Their work also cautions how such prospects can be severely compromised in unequal, agrarian social orders that exert persistent influence on resource access and knowledge systems in general and agrobiodiversity use in particular.

The works of Louise Sperling, Shawn McGuire, and others highlight the potential of seed aid as a potent force for impacting agrobiodiversity initiatives among refugees and displaced persons (McGuire 2008; McGuire and Sperling 2008; Sperling and McGuire 2010). McGuire recently noted that "in practice much seed aid comes as direct (free) distribution of seed, usually of a handful of formal sector varieties.…[S]uch forms of seed aid commonly target large-scale displacement and resettlement situations (e.g., northeastern Nigeria at the moment)" (McGuire, pers. comm.).

Human migration related to agrobiodiversity also incorporates the biotic movements of plants, animals, and agroecosystems, a general perspective that has been widely applied to environmental history (Carney and Rosomoff 2009;

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Crosby 1986; Rangan et al. 2015). Populations of these organisms typically undergo diversification through migration and genetic-level integration as illustrated by the peninsular oases of California (De Grenade and Nabhan 2013). Other results of migration, such as genetic bottlenecks, can severely restrict the biodiversity of plant and animal populations as well as limit the capacity for subsequent evolution. More generally, it is important to understand the interactions between agrobiodiversity and human migration as well as other forms of demographic change and spatial integration by employing the perspective of crop metapopulations rather than the narrowly defined notions of varieties and species (Alvarez et al. 2005; Orozco-Ramírez et al. 2016; van Heerwaarden et al. 2010; Zimmerer 1998).

Agricultural Trade, Markets, and Food System Integration

Agricultural trade growth and spatially integrated food and seed systems in the context of world population growth and globalization have fueled the connectivity of world markets. The resulting flows of standardized seed and immense quantities of food into global agrobiodiversity centers of production and consumption have reduced the genetic diversity of crops and agrobiodiversity in staple food agriculture and weakened associated smallholder farming systems (Lockie and Carpenter 2010). Food imports include frequently subsidized processed foods and food staples representing a narrow range of biodiversity that are inexpensively produced in the Global North.

The impact of this trade-dumping is mostly negative on the agrobiodiversity of staple foods, although these linkages need to be systematically investigated. Similarly, the market imports of seeds, such as vegetable seeds, seem for the most part to represent the ascendance of a narrow suite of crop species and varietal types at the expense of a broader, existing agrobiodiversity. Increased global integration of the trade of agricultural seeds and its basis in exclusive patenting and intellectual property rights has been highlighted in recent work as offering some of the most potent threats to food security and agrobiodiversity in Africa and other world regions (AFSA 2017). Here, too, there is the need for careful, well-designed studies, including ones based on historical research frameworks (discussed below).

Seen across geographic scales, the variation of agrobiodiversity outcomes—ranging from the global trend of a sharp reduction in staple food diversity to a continuing emphasis on diversity in certain local markets—is notable with regard to the impact of the food trade. The impacts of agricultural trade combining low-agrobiodiversity imports with more complex local food systems does enable agrobiodiversity to prevail in some markets (Bellon and Hellin 2011). It is not the dominant pattern, but tends to result in the availability of agrobiodiversity of moderate levels in rural-migrant neighborhoods in the Global South (e.g., Van Andel and Fundiko 2017). One of the key features of

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these markets—many of which are informal markets—is that they tend to entail well-established social relations and complex offerings of at least moderate levels of varietal diversity within staple foods as well as less common species. This feature is important because the continued marketing of intraspecific varieties (also known as local cultivars or farmer varieties) enables the integration of consumer demand and production that is vitally important to both the agroecological and sociocultural functions of sustainability involving agrobiodiversity (Kawa et al. 2013; Temudo 2011; for a contrasting interpretation, see Van Dusen and Taylor 2005). Moreover, this feature is a contrast to many global food trends that can appear to stimulate agrobiodiversity and potential sustainability benefits, but that in reality rely on a narrow range of varieties within a few novel food species.

The global "Quinoa Boom" is a good example of this phenomenon of the spatial integration of markets involving agrobiodiversity albeit with complex and often unanticipated consequences (Oberlack et al. 2016; Walsh-Dilley 2013). It has resulted from the rising demand of consumers—principally in the United States and Europe—together with responsive and highly integrated supply chains involving producers, distributors, and investors. These conditions have led to the rapid and widespread expansion of quinoa production concentrated in the southern Altiplano of Bolivia and extending through the Andes of Bolivia and Peru and, to a lesser degree, of Ecuador, Colombia, and northern parts of Argentina and Chile. Much of the global market involves a single variety known as Quinoa Real, and production often entails simplified agroecosystems relying on monoculture and continuous cropping. In addition, it has led to the severalfold increase of market prices: 600% between 2000 and 2008 (Ofstehage 2012). As various researchers have discovered, however, the home consumption of quinoa remains vibrant amid many Indigenous peasant farmers who are among the main producers (Kerssen 2015), even in the core producing areas of the Quinoa Boom (Oberlack et al. 2016; Walsh-Dilley 2013). This fact, along with conflicting interpretations of environmental data, has stimulated scientific debate and still unresolved conclusions regarding the environmental impacts remain, including agrobiodiversity loss as well as the social consequences (Jacobsen 2011; Winkel et al. 2012).

The spatial integration globally of industrial food systems has recently begun to be measured, and estimates show pronounced impacts on agrobiodiversity (Khoury et al. 2014). This new research seeks to estimate agrobiodiversity levels at multiple scales (including countries) and, in some cases, to determine the relationship between food system biodiversity and the dietary diversity of different socioeconomic groups within a country. It promises empirically derived policy information and insights that can be used to clarify and address the challenges of food and nutritional security in general and dietary quality specifically that are faced in the ongoing changes of agrobiodiversity in global food systems as well as those at smaller geographical scales (AFSA 2017; Bioversity Intl. 2017; HLPE 2017; IPES-Food 2017).

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Even so, the expanding spatial integration of agricultural trade worldwide may be more complex than imagined. Recent U.S. agriculture missions to Cuba include a congressperson who advocates continuation of the country's policy support for its organic farming system rather than a return to conventional large-scale farming. This shift to organic food production began in the early 1990s following the breakup of the Soviet Union and the loss of the Soviet oil subsidy, which had encouraged the export of traditional monocrops. As Cuba's oil-dependent, mechanized, large-holding sector collapsed, the country reorganized agriculture, turning away from monocultures (especially sugarcane and citrus) grown for export to organic farming of basic foodstuffs on smaller farm units to feed its population. The export monocrop agriculture model has long limited Cuba's political options. Prior to the Cold War, large-scale farms produced tropical export crops for the U.S. market.

Following the Cuban Revolution and the ensuing nationalization of large landholdings into state farms, the Cold War political realignment oriented the traditional export sector to the Soviet Union. This continued the country's dependency on imported food while doing little to improve regional food availability. The dissolution of the Soviet Union brought the historic pattern to an end, forcing Cuba to prioritize feeding itself. This was achieved by turning the large and centralized state farms into small and decentralized cooperatives with an emphasis on food sovereignty. With more than twenty years' experience growing food organically, Cuba is now at a critical, historical crossroads. The recent détente with the United States holds considerable promise for a new export model based on organic food. While organics represent a small proportion of total food purchases in the United States (5% on average), it is the fastest growing food sector. Cuba's export of organic fruits, vegetables, coffee, sugar, and citrus could potentially increase the trade of intermediate levels of agrobiodiversity while earning valuable foreign exchange (Severson 2016).

Spatial and Land-Use Planning, Zoning, Territorialization, and Social Movements

Spatial and land-use planning, zoning, and territorialization in towns, cities, individual countries, and regional political and economic unions often bring about spatial changes. These activities commonly comprise the spatial integration associated with globalization, whether economic, political, or environmental in nature. Often, they also concurrently create or exacerbate spatial differences. Territory-based and territory-focused social movements play an important role in drawing attention to these differences. Such movements include many peasant and Indigenous groups who perceive the powerful entwining of territorial rights and claims to agrobiodiversity production and consumption. Their combined claims to territorial rights and efforts to protect

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and control resources, including agrobiodiversity and corresponding seed systems, constitute the powerful linkages created by local groups and global organizations (de Wit 2016; Zimmerer et al. 2017).

Modern land-use planning, zoning, and territory-based resource management have tended to place negative pressures on agrobiodiversity through state-led paradigms of improvement and governability. The spatial impact of the current leading global initiatives for food security and agricultural modernization is explicit and implicit (e.g., the "New Green Revolution," "Next Green Revolution," and "Agriculture for Africa"). Various other sustainability and agricultural modernization campaigns, especially but not only in Africa, have also left powerful spatial imprints by combining direct and indirect designs (discussed below). The European Union's reformed Common Agricultural Policy is another important example that expects benefits to agrobiodiversity whilst relying on land-use planning (Overmars et al. 2014).

Land-use planning at the national level is presumed to exemplify this negative impact on agrobiodiversity but merits additional in-depth study (Dawson et al. 2016b). More generally, the growth of sustainability goals, participatory approaches, and enhanced territory and property definitions during the past decades are mentioned more often in new government-based planning projects (though far from a priority in the latter) as well as nongovernmental initiatives.

The impacts on agrobiodiversity of these initiatives are still uncertain, since even village-level land-use planning tends to exert little influence on agricultural decision making (Lestrelin et al. 2011). Nonetheless, these new projects and policies have the potential to create a positive influence on local access to resources, especially land and water. In turn, such enhanced resource availability impacts agrobiodiversity. Such projects and policies vary widely and important critiques have been applied from the still-expanding *ordenamiento territorial* in Latin America (Zimmerer 2017b) to the *gestion des terroir* approach in West Africa (Bassett and Gautier 2014). The combination of social participation and territorial approaches can potentially become beneficial for local resource access and agrobiodiversity outcomes.

A specific focus on agrobiodiversity has also been incorporated into zoning and hotspot mapping. These forms of spatial integration are being used for planning the zonation of land use and the prioritization of efforts aimed at the continued use and conservation of agrobiodiversity. One national-level example is the initiative spearheaded by Peru's *ministerio del ambiente* (MINAM). MINAM is currently involved in building a program for the application of zonation and other planning models to enable the sustainability of agrobiodiversity. Among the goals of MINAM is to create zonation models that will enable the continued use and conservation of agrobiodiversity while protecting such areas from potential gene flow associated with the production of genetically modified types of crops.

At the same time, these planning and zoning decisions alone need to be seen as a necessary but not sufficient means of contributing to local governance and

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sustainability initiatives that favor agrobiodiversity. In other words, specific factors occurring in conjunction with planning and zoning (such as access to land and water, especially among smallholder and Indigenous or traditional populations) are particularly important to agrobiodiversity outcomes. In sum, the evolution and adoption of planning, zoning, and territory-based resource management have expanded considerably in the past couple of decades. These approaches are likely to continue to grow, increasing their power to influence ongoing spatial integration. The propelling forces include sustainability goals concerned with the world "running out of farmland" and the associated increase in land investments and "land grabs."

Food Security, Food Sovereignty, Sustainable Intensification, and Ecological Intensification

Spatial integration also occurs via the policies and knowledge systems—existing and planned—that combine sustainability with global food security and sovereignty. Research on ways to promote food security through ecological (Tscharntke et al. 2012) and sustainable intensification (Garnett et al. 2013) has identified the central role that biodiversity, including agrobiodiversity, plays in providing agroecological functions and resilience that can close the yield gap without incurring major environmental impacts. In particular, ecological and sustainable intensification recognize that agroecosystems' biodiversity furnishes much-needed agroecological services and agroecosystem regulatory functions. According to Vanek (Chapter 4), landscapes with greater levels and scope of biodiversity and agroecological functions are generally more productive, self-regulating, and resilient than those with lesser levels (see also Delaquis et al. 2018; Jackson et al. 2007; Jarvis et al. 2007).

Global-level ideas and potential policies for food security and sovereignty both extend their emphasis on agroecological functions and traits to encompass human diets, nutrition, and health. Food security policies interlink the goals of human nutrition and health with income generation and access to high-quality foods. Food sovereignty ideas and movements, which have been growing in global significance, meld the aforementioned functions with prioritizing the need to forge the independence of agrifood systems by controlling access to their agrobiodiversity, its use and benefits (see also Chapter 14). The broad spectrum of goals within food security and food sovereignty suggest ample scientific and policy opportunities to examine and encourage agrobiodiversity.

The sociocultural and ecological processes inherent in global change drivers are integral to research on food security and food sovereignty's prospects and pathways. Creating and sustaining viable, high-quality local seed systems, for example, must respond to the need for valued foodstuffs and foodways while replenishing productive capability and providing adaptive capacity in the face of climate change and other drivers (see also Chapter 7).

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These areas of research highlight the contextual and spatial variation in ecological and sustainable intensification that include high-yield and medium-intensity agriculture. This creates new research opportunities for intensity-related incorporation of agrobiodiversity and agroecological approaches (Jordan and Davis 2015). For example, the functions of agrobiodiversity under the socioeconomic and environmental conditions of medium-intensity cropping can involve seeding with larger numbers of varieties, thus reducing risk and also producing higher yield than less diverse cropping (Di Falco et al. 2010). Other functions include provisioning specialized food and market products.

In addition, cultivation for enhanced agrobiodiversity can be compatible with crop commodity specialization in medium-intensity production (Flachs 2015; Turner and Davidson-Hunt 2016; Zimmerer 2013). Analysis of this compatibility amid intensification will require new research and the application of concepts and models of agricultural and economic development that address farm-level rationales that combine risk management and poverty alleviation via income generation (Barrett et al. 2010).

Intensification approaches (both ecological and sustainable) incorporating agrobiodiversity in medium-intensity agriculture may lead to increased insight into ecology, cultural practices, local knowledge systems, and continued coevolution. This evolutionary ecological research is using molecular-level tools and techniques to vastly expand understanding of the deeply entwined cultural and ecological complexity of agrobiodiversity (Bradbury and Emshwiller 2011; McKey et al. 2010a; Orozco-Ramírez et al. 2016; Vigouroux et al. 2011a). With a new era of discovery around plant and animal microbiomes just having started, the potential to generate new insights with practical implications for ecological and sustainable intensification is substantial (Köberl et al. 2015; Sessitsch and Mitter 2015).

Finally, agrobiodiversity's socioecological processes in ecological and sustainable intensification suggest functions that are both similar to and yet distinct from those belonging to the general field of agroecology. Further research is needed to clarify and strengthen their complementary roles, as well as our vision of the possibilities for agrobiodiversity and agroecology.

Historical, Cultural, and Social Network Considerations

Historical and cultural perspectives provide additional insight into the interactions between agrobiodiversity, demographic change, and spatial integration. In the past, many combinations of trade, migration, and landscape change involving food and food traditions significantly enriched agrobiodiversity and supported cultural practices and religious belief systems. One specific example is the agrobiodiversity that emerged in African and South Asian agrifood systems connecting pre-European (and pre-Islamic) trade networks around

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the Indian Ocean, roughly between 800 and 1500 C.E. (Rangan et al. 2015). Counterexamples are also abundant, as in the case of European livestock and pasture flora that were spread across many of the world's temperate zones during colonization in the nineteenth and twentieth centuries, devastating native species (Crosby 1986). Within Britain, agrobiodiversity has been affected by a range of forces, including but not limited to seed commodification in Europe, allotment growing, seed saving, and de-skilling of the contemporary workforce. Such factors have resulted in agrobiodiversity loss or, at the least, shown complex and potentially unfavorable interactions with farm management and food production (Aistara 2011; Gilbert 2013).

These considerations can be extended to more extreme examples and also to present-day demographic change and spatial integration. For example, enslaved African rice growers in the United States and other locations were able to use marginal environments of little value to slaveholders to grow this crop for subsistence (Carney 2001; Carney and Rosomoff 2009). This example highlights the importance of cultural knowledge systems, social interactions, and power relations within and among groups (slaves, slave communities, plantation managers and owners) as well as new forms of intensification that can result from heterogeneity among smallholder farmers.

In our own times, a confluence of enabling factors can lead to favorable levels of agrobiodiversity in landscapes of migrant or refugee agrobiodiversity growers and consumers (Zimmerer 2014). More generally, the dynamic contexts of demographic and technological change have created circumstances where some households and communities have been able to continue the use of agrobiodiversity while they intensify production. In these cases, the practice of sustainable and ecological intensification has demonstrated emergent compatibility with the continued utilization of agrobiodiversity (Flachs 2015; Turner and Davidson-Hunt 2016; Zimmerer 2013).

Whether individual producers and consumers and their communities continue to conserve agrobiodiversity in contexts of migration depends on such factors as their capacity to participate in social networks, the amenability of the host government to help them do so, and different forms of seed exchange and acquisition. Where agrobiodiversity transfer is facilitated and plant health is protected, the social linkages in migration can facilitate further coevolution of agrobiodiversity through connecting the networks of otherwise separate seed systems. While past plant exchanges were the result of extraordinary journeys (Roullier et al. 2013a; Van Andel et al. 2016), globalization and increased connectedness has accelerated germplasm flows. Social networks and the other aforementioned factors are similarly important in the transitions to part-time and peri-urban farming that have created increasingly new and different conditions for agrobiodiversity during the past couple decades (Ellen and Platten 2011).

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Conclusion: Directions of Future Research on the Interactions of Agrobiodiversity with Demographic Changes and Spatial Integration

Drivers of demographic change and spatial integration are vitally important to understanding the challenges facing agrobiodiversity. Current agrobiodiversity outcomes, ranging from genetic erosion and the creation of new diversity to continued use and conservation, are highly dependent on the interactions with these drivers. Specific, major drivers include human population changes, urbanization, globalization (e.g., migration, agricultural trade, and food system integration and transitions), spatial planning, potentially widespread approaches to food security and sovereignty, and a broad swath of historical, cultural, and social network considerations. Several of these drivers have powerful historical antecedents that also have importance to agrobiodiversity, both in understanding the past and processes that continue to exert influential legacy effects.

A number of the current drivers of global change tend to bear indeterminate relations to agrobiodiversity that depend on intervening and intermediate-level factors rather than enacting ironclad outcomes. Drivers such as population growth, migration with continued part-time farming, urbanization, and narrow plant selection responses to climate change can and often do weaken and undermine agrobiodiversity. Conversely, certain supporting conditions are comprised of factors potentially occurring together, such as resource access, innovative knowledge systems, and continued culinary value and use at the household and individual levels. These combined conditions can function as intermediate-level modifiers of global change drivers that support the continued demands for agrobiodiversity and the potential future expansion of its utilization.

Engaging policy and practitioner communities is a high priority (e.g., AFSA 2017; Bioversity Intl. 2017; HLPE 2017; IPES-Food 2017). Our chapter is keen to expand interactions with several of these communities involved in the Second Global Plan of Action for Plant Genetic Resources, the Convention on Biological Diversity (CBD), and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) as well as other robust policy networks. Researchers need to be partnered with organizations to ensure that much-needed scientific analyses and scholarly understandings of global drivers and their impacts on and interactions with agrobiodiversity across multiple scales are able to be channeled into concrete policy insights, creating potentially new opportunities for more sustainable food futures worldwide.

We must recognize, moreover, that expanding the intermediate-level understandings of the varied processes inherent in agrobiodiversity change will increase the complexity of research. Therefore, the development and application of change and complexity-sensitive concepts is urgently needed in

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agrobiodiversity research. Conceptual frameworks such as geographic synthesis, socioecological systems, global change analysis, complex adaptive systems, coupled human–natural systems, and historical agroenvironmental studies have the potential to be particularly well-suited to understanding this complexity. In addition, future studies are needed to ascertain whether, or to what degree, the complexity of agrobiodiversity systems can be addressed through promising action research and design perspectives (see Chapter 7).

One crucial area of policy-relevant research is historical analysis that leads to a better understanding of the specific conditions that support agrobiodiversity amid dynamic demographic changes and spatial integration. Future agroenvironmental historical research can help address the aforementioned challenges of complexity in agrobiodiversity change. It is needed, for instance, to gain insight into the processes and patterns of recent refugee movements that have incurred both agrobiodiversity use and disuse (e.g., Vietnamese and Laotian refugees in the southern United States). These broader historical research themes will need to be complemented by specialized studies. For example, historical information needs to be uncovered and clarified that can serve as baseline data for in-depth temporal comparisons which in turn provide the foundation for potential monitoring systems (Pereira and Cooper 2006; see also Chapter 5).

Another area of crucial future research is to take the multiple dimensions of demographic change and spatial integration surveyed here and apply them to the actual dynamics of agrobiodiversity. Having recognized potential compatibility, future studies must reconsider agrobiodiversity research topics that previously focused primarily on so-called traditional agriculture in seemingly remote cultural contexts. Take, for example, the topic of seed networks. New research is urgently needed on the seed exchange networks of large groups of agrobiodiversity growers who are living in urban and expanding peri-urban areas amid migration processes, including refugees.

At the same time, novel research is needed to examine the characteristics of agrobiodiversity in these new, expanding contexts. It should consider agrobiodiversity-focused factors, such as whether and how varietal and species-level diversity and agroecosystem functions are being altered together with demographic change and spatial interactions. More generally, innovative agrobiodiversity research that implements the insights identified above should be able to make comparisons across space and time between agrobiodiversity systems. Such comparative research will certainly need to be mindful of variations, both conspicuous and subtle, that are contained in diverse manifestations of agrobiodiversity knowledge among countries, cultures, and time periods.

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