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INTERACTIONS OF MIGRATION AND POPULATION DYNAMICS WITH ECOSYSTEM SERVICES

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Introduction

The demand and supply of ecosystem services interacts with population dynamics within social-ecological systems. Yet the intricacies of population dynamics are ignored or lost in aggregation in many analyses and models. The decline in ecosystem services globally is partly explained by the issue of scale: greater human population in aggregate, and the changing distribution of these populations across different ecological regions, leads to greater pressure on ecosystems for productive use, pressure on habitats for settlement or agriculture, and greater pollution. But studies have demonstrated that only considering the total number of people has a limited role in explaining specific aspects of resource decline, and indeed high population density can in itself create the incentives for sustainable resource use. Hence a critical examination of the relationship between ecosystem services and population dynamics reveals key demographic processes. In particular, we emphasise here the role of migration as a social phenomenon predominantly of deliberate, voluntary change of residence, either permanently or temporarily, that has complex interactions with wellbeing, poverty and ecosystem services that are transformative of individuals and societies.

The analysis of interactions between ecological and social dynamics suggests that because ecosystem services are variable in space and time, human populations adapt to such processes through their own mobility. Rapid demographic and environment changes interact with development interventions with likely consequences for ecosystem service use and wellbeing. We highlight, in particular, that the dominant migration flows observed globally, especially from rural to urban areas, have profound consequences for ecosystem service access. This chapter outlines such relationships and suggests that development planning and interventions need to account for the spatial distribution of populations, the structure of populations and their mobility and migration patterns.

Spatiotemporal variability, mobility and ecosystem services

Mobility of ecosystem services and contemporary response strategies

Ecosystem services are mostly researched, particularly in terrestrial environments, as ecosystems or linked social-ecological systems situated in a place. Typically, a system is bounded geographically to an area within which ecosystem services and institutional arrangements are assessed (Pascual et al., 2017). Many studies involve snapshots of one or two ecosystem services at a single moment in time. Yet, ecosystem services are highly variable and mobile in space and time (Renard et al., 2015).

Environmental processes vary temporally and spatially: hence the services they provide are also variable. Rather than a steady, linear supply, which is often assumed in assessments, ecosystem service provision is dependent on dynamic, non-linear relationships between ecosystem stocks and flows (Koch et al., 2009). For example, marine ecosystems fluctuate daily, seasonally and inter-annually in response to seasonal oceanographic changes due to physical-chemical conditions and diurnal and seasonal vertical and lateral migrations of marine life (Drakou et al., 2017). Similarly, seasonal and erratic rainfall and climate extremes drive fluctuations in water and forage availability in drylands, resulting in mass migrations of wildlife and livestock (Fernandez-Gimenez and Le Febre, 2006). Because of this variability, ecosystem service benefits often only manifest at very specific times in annual or other temporal cycles, for both provisioning and regulating services. For instance, wave attenuation capacities are affected by intra-annual changes in the density and biomass of seagrasses (Chen et al., 2007).

Ecosystem service variability can create uneven patterns of income and consumption in natural resource-dependent households, which leads to seasonal or periodic poverty. Because of climatic seasons, farming households often have periods of the year for harvesting and selling crops, income from which is saved and used over the intervening months, and periods of hardship when savings are spent and crops have not matured for sale. Similarly, unpredictable variability in climate and ecosystem service supply increases the risk of households falling into, or failing to escape, poverty. In rural coastal Bangladesh, for example, households living in persistent poverty tend to have high seasonal variability in their incomes. This suggests that ecosystem service variability and seasonality poses risks to households falling into poverty and can limit the potential of ecosystem services to provide pathways out of poverty. For example, variability and declining overall forest integrity for the Sunderban mangrove forests in Bangladesh projected over the coming decades (Payo et al., 2016) challenges the role of ecosystem services as a safety net for coastal populations.

Human mobility is a key social response for dealing with such spatial and temporal variability in ecosystem services, income and consumption. Figure 5.1 shows temporal and spatial patterns of mobility in fisheries and pastoralist social-ecological systems. Livelihood studies have documented the critical role of migration in reducing vulnerability and poverty in low-income countries (Ellis, 1998). Seasonal migration enables households to benefit from seasonal patterns of food production and labour demand elsewhere to cope with local variability at home (de Haan, 1999). Many small-scale fishers in developing countries move in response to the seasonal movement or availability of fish to maintain their income (Figure 5.1(a)). On Lake Victoria, East Africa, about 60,000 fishers, around half of all boat crew, move from beach to beach for 2–3-month periods to access higher productivity fishing grounds and landing sites that command higher prices (Nunan et al., 2012).

Circular migration can help households diversify their livelihoods to cope with seasonal variability in climate and ecosystem services, such as when farmers take non-farm jobs in the city during the offseason. In India, approximately 20 million people temporarily migrate each year, mostly from drought-prone areas with rainfed agriculture to irrigated cropland (Deshingkar, 2006). Circular migration is driven by economic, cultural and social factors, as well as ecosystem service variability. Pastoralists, for instance, move, not just to access more productive pastures, but to reach markets and interact with other families and tribes to build social ties and make social exchanges such as marriage (Fernandez-Gimenez and Le Febre, 2006). Rotational migration involves movement to avoid or respond to ecosystem service overexploitation. Slash-and-burn agriculture in Amazonia, rotation of livestock between pastures to avoid overgrazing, and rotation of fishing activity within a space provide examples of this type of mobility. Beitl (2015), for example, observed how artisanal shellfish harvesters in the coastal mangrove swamps of Ecuador move to new grounds when their catch rates fall below average, with potential benefits of allowing habitats and stocks to recover. Such mobile practices are often deeply embedded in social practices and entwined in strategies that secure livelihoods (de Haan, 1999).

Livelihood mobility occurs across a range of scales (Figure 5.1(a),(b)). In the small-scale fisheries, some mobility is daily and localised, such as when fishers travel to the shoreline by foot or motor vehicle and to local fishing grounds by boat. Many fishers, however, migrate to distant waters to take advantage of spatial and temporal variability in fisheries productivity across seascape or jurisdictional and national boundaries. Similarly, the scale of transhuman pastoralism can vary from a limited landscape such as a valley to large-scale transboundary areas.

Mobility and flexibility is a well-documented livelihood strategy to cope and adapt to environmental variability, yet the interconnections between ecosystem services and livelihood mobility have not been considered in ecosystem service research, despite the obvious implications for ecosystem service uses and experiences on the transit routes and sites of out- and in-migration.

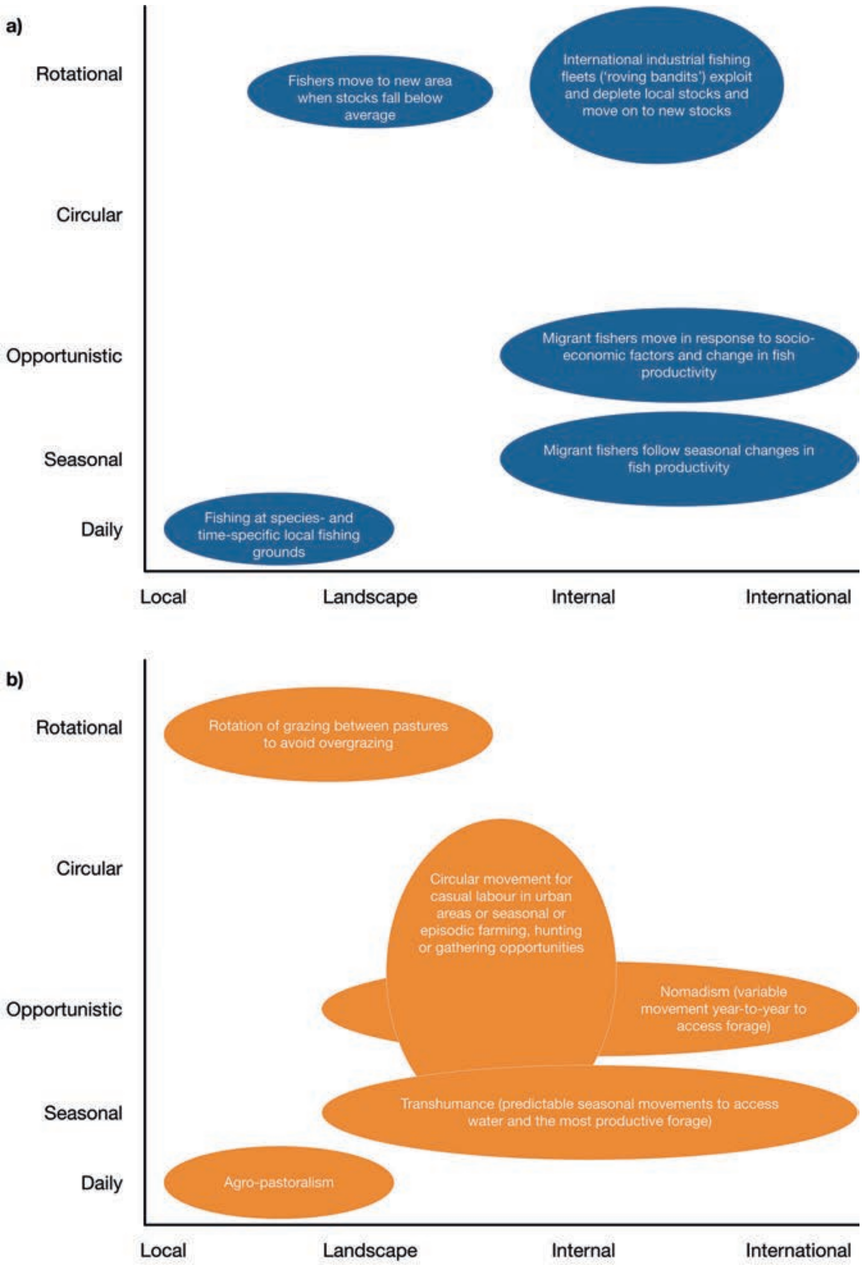

FIGURE 5.1 Spatial and temporal variability and mobility of (a) fisheries and (b) rangeland ecosystem services and livelihoods.

Challenges to governing mobile ecosystem services and livelihoods

Ecosystem management is often organised as common pool resource institutions, such as co-managed or community-based protected areas, based on local governance creating a vested interest in the provision and sustainable management of local ecosystem services. Mobile ecosystem services and human populations, however, challenge this governance model by disconnecting resources and resource users from the place of management. For example, in the Western Indian Ocean, marine protected areas and local fisheries enforcement have been established to address declining fish stocks. However, fishers cross local and national boundaries in search of mobile fish stocks, making monitoring the movement of migrants (Wanyonyi et al., 2011) and the management of fishing effort in a demarcated area problematic (Nunan et al., 2012). Berkes et al. (2006) describe mobile fleets of fishers and traders as roving bandits, who target and deplete stocks of valuable marine species and then move to new areas to exploit other stocks. Small-scale, local governance arrangements do not match the scale of mobility of these fisheries driven by global demand and technological changes in fishing practices. Migrant fishers then have little incentive to participate in management institutions that depend on attachment to place and, in a globalised world, the rate that new markets and technologies emerge outpaces the ability of local institutions to adapt.

Place-based protected areas often struggle to conserve mobile fisheries and wildlife as they are too small, scattered or disparate to match the behaviour of migratory species, and enforcement and monitoring outside of the protected areas is too weak. Common pool resource management institutions are therefore effective at managing species that are sedentary or not very mobile at local or landscape levels, but not for highly mobile ecosystem services and livelihoods.

Common property institutions that constrain mobility may also be counter-productive for poverty alleviation in some contexts, given the critical connections between human mobility, livelihoods and ecosystem services for the wellbeing of the poor. In pastoral systems, for instance, common property resource institutions are often mismatched with the changing availabilities of forage and water over space and time, and thus the needs of pastoralism (Brottem et al., 2014). In fisheries, migrant access to a fishery may be impeded by permits, licences or membership of local institutions.

Mobile actors are often excluded or unable to participate in local governance. The creation of co-management arrangements on Lake Victoria sought the participation of key stakeholders in decision making and management. However, given the mobility of the boat crews, their effective participation was problematic, with co-management instead dominated by powerful boat owners (Nunan et al., 2012). Co-management literature provides little guidance on how to deal with such mobile resource users. The large-scale and/or transboundary movement of pastoralists is also often not considered in conservation and natural resource management, which tends to target sedentary agricultural populations that are in conflict with pastoralists (Binot et al., 2009). Conditions of high rainfall and forage variability require flexible rules and limited social boundaries to maintain pastoral mobility (Brottem et al., 2014); this is at odds with the dominant place-based management of ecosystem services.

Ecosystem management institutions have not yet evolved to cope with the complexity and diversity of ecosystem service mobility. Berkes et al. (2006) suggest multi-level governance as a solution. This would involve managing ecosystem services and connecting institutions across local to international levels, and accounting for the interests and views of migrants in decision making. Mobile ecosystem services and resource users can potentially be integrated into multi-level governance systems: experience from schemes such as the international Coral Triangle Initiative involving six countries suggests that coordination is challenging even to avoid conflicts and maintain regulatory cohesion (Fidelman et al., 2014).

Migration decisions, migration outcomes and ecosystem services

Migration as a social system

Migration is a multifaceted social system that has complex interactions with wellbeing, poverty and trajectories of capital accumulation. Voluntary migration encompasses choice: permanent movement to exploit economic opportunities, both domestically and internationally, and circular movements of people between source and destination areas. Movement of people to urban centres within their own countries represents the single largest contemporary migration flow. But some migration arises from a lack of agency and choice: involuntary displacement due to conflict, coercion by governments or because of environmental degradation.

Does voluntary migration represent a universal pathway out of poverty for those involved in it? Most migration theories and empirical studies point to the motivations for migration as involving expectations of increased wellbeing, both in economic and social terms. When individuals leave home and form new households in distant locations, economic models conceptualise this action as an intra-household contract so that migration compensates for or benefits the household overall (Taylor, 1999). It is well established that migration, at the aggregate level, increases economic growth in, and economic linkages between, source and destination areas through remittance income (de Haas, 2005), and increases wellbeing and life satisfaction among those moving location (Nowok et al., 2013). The evidence is diverse across the social and economic sciences.

Dimensions of the migration–ecosystem service relationship involve issues such as how remittance income is invested, and how new populations in rural frontiers or in urban areas access ecosystem services, including the role of ecosystem services in creating wellbeing for migrant populations. Most migration-environment research focuses on the relative influence of resource scarcity, extreme events and environmental change on individual decision making or on aggregate flows of people, or the prospect of migration as adaptation to environmental harm (reviewed in Adger et al., 2015). The key parameters of how ecosystem services, environmental change and migration interact within social-ecological systems is not conceptualised in consistent or comprehensive ways. Here we examine each of the issues in turn.

Ecosystem services in source-destination linkages

Migration leads to increased economic linkages between where people move from, and where they eventually reside: source and destination areas. Indeed, migration studies have shown that most individuals leave households to gain employment and resources to return to their original households. Remittance flows from temporary or international migration sources are maintained over many years, which stems from migrants wanting the fall-back option of returning to their place of origin and to ensure the maintenance of land and other assets that they may inherit. Remittance income, unlike seasonally variable resources or agriculture-dependent livelihoods, is often constant over the course of the year, and hence can smooth income or consumption levels (Ellis, 1998). More importantly, remittance income tends to be invested in capital, such as in human capital through education or entrepreneurship, rather than being used principally for consumption (Hoddinott, 1994). Thus seasonal and circular migration have several interactions with ecosystem services. The out-migration of adults clearly reduces labour in source areas, making the exploitation of ecosystem services more difficult, but this is offset if adults travel back for important harvest times or to maintain ecosystems. Perhaps most importantly, remittance income can be invested in ecosystem-conserving technologies, or in greater exploitation and degradation of ecosystem services.

The evidence suggests that both ecosystem service enhancement and ecosystem service degradation result from temporary migration and investment of remittance income. Qin (2010) shows, for example, that out-migration of household members in rural parts of Chongqing region of China enhances the wellbeing of those households compared to those without migrant sources of income. However, among migrant households, there is some land abandonment due to labour shortages, which may explain the rise in forest cover in the region from 10% in the 1960s to 24% by 2008. Contrary conclusions are drawn by Gray and Bilsborrow (2014) from analysis in rural Ecuador, where agricultural areas have increased rather than being abandoned as a response to labour out-migration. In fact, there is evidence that out-migration can result in investment in sustainability. Hunter et al. (2014) show that temporary migration from rural areas in South Africa allows investment in natural capital by those households involved. Not all remittance investment leads to greater sustainability, however. Adger et al. (2002) documented how remittance flows supported the expansion of high-value but risky conversion of mangrove areas to aquaculture in northern Vietnam.

Ecosystem services in migration decisions

So while migration affects the demand and supply of ecosystem services, how important are ecosystem services for decisions concerning migration? Migration decision-making models show that the principal drivers of decisions to move are related to economic and educational opportunities, and barriers and risks to staying and going (Black et al., 2011). Ecosystem services play a role in such calculus, because they affect the landscapes of opportunity and risk in both source and destination areas. Migration decisions involve social disruption and feelings of loss and grief concerning places where people leave. Some of this is associated with place and place utility: in effect, cultural ecosystem services are part of the landscape of meaning and attachment of places people leave. Sense of place and attachment to place emerge from interactions with the physical and biological environment as well as through social relations: ecosystems have value through those relations in places (Masterson et al., 2017). Adams (2016), for example, explains how farming populations remain in upland Peruvian highlands due to cultural ecosystem services, such as perceptions of land and landscape, whereas standard models and calculus would suggest otherwise. Similarly, Mortreux and Barnett (2009) document the cultural and attachment reasons for populations deciding not to migrate internationally from Tuvalu in the Pacific. In other words, ecosystem services beyond their material value maintain value and indeed maintain populations within landscapes of social-ecological interaction.

Does migration lead to pressure on ecosystem services?

Temporary and circular migration from rural areas to cities and urban centres remains the single most prevalent migration flow globally. It has, then, significant and offsetting roles in the maintenance of ecosystem services: migration may enhance poverty alleviation, but the interaction with ecosystem services depends on how investments directly affect the exploitation and sustainability of resources.

While global migration flows are dominated by rural–urban movement, continued movement to new resource frontiers, particularly to forest frontiers, directly affects ecosystem services. López et al. (2006) argue that high fertility rates among remote farming communities in Latin American forest frontiers have a disproportionate impact on forest conversion, and that forest frontier migrants remain the main proximate cause of deforestation. López-Carr and Burgdorfer (2013) suggest that large family sizes also generate high levels of next-generation migration to new frontier areas. The effect of migration to forest frontiers on rates of habitat decline is, however, a complicated picture: in many remote forest frontiers, such as in Amazonia, there is evidence of continued depopulation as people move to urban areas for greater economic opportunities (Parry et al., 2010), yet rural-to-frontier migration remains a major trend. The impact of such migration flows on ecosystem services relates to how frontier migrants gain access to and knowledge about ecosystem services in their new locations, and whether their effects on ecosystem services are above average for the aggregate population.

There is much evidence on how habitat loss from land conversion reduces local ecological knowledge in frontier environments: Kai et al. (2014) show how younger populations can identify fewer forest species than older generations in forest frontiers in China. But new migrants gain knowledge through experimentation and experience. Muchagata and Brown (2000) show how migrant farmers in eastern Amazonia gain detailed taxonomic knowledge of their forest and pasture environments. Meyfroidt (2013) shows, however, that moves towards sustainable land use practices in Vietnam significantly lagged behind any new knowledge of environmental degradation and increasing scarcity of ecosystem services.

Given that knowledge and access to ecosystem services is not sufficient for conservation practices in new populations, other incentives come into play. Jones et al. (2018) provide evidence that new migrant populations in forest frontiers in Madagascar are attracted by land availability, but are no more likely than established populations to clear forest land: in other words, they are not so-called exceptional forest degraders. Garrett et al. (2017) suggest for frontier agriculture in Amazonia that agricultural intensification opportunities need to align with activities that bring non-material wellbeing and build on the identities of the farming communities, rather than relying on out-migration to bring about a forest transition.

Role of migration and displacement associated with loss of ecosystem services

How does the loss of ecosystem services affect migration processes – do they amplify or attenuate ongoing and established migration flows? Loss of ecosystem services may occur due to either sudden-onset natural hazards or long-term modifying processes, such as land degradation or sea level rise. The distinction is important, because natural hazards are a major source of involuntary displacement of populations. By contrast, long-term ecosystem degradation interacts with economic factors leading to conscious decisions to migrate from such areas (Renaud et al., 2011).

Displacement is a common phenomenon, with about 26 million people forced to vacate their homes and settlements every year because of disaster events such as floods, tsunamis, tropical storms, droughts or wildfires (IDMC, 2015). In addition to loss of infrastructure, loss of shelter and risk to life, these events disrupt the provision of ecosystem services, with the potential to displace people. For example, a drought may affect crop and livestock productivity, causing food insecurity or famine that displaces local populations. The exposure of a population to a hazard is also affected by the loss of regulatory services. For example, two million people were displaced by the 2004 Asian tsunami; settlements, water resources and cultivated areas were better protected where mangrove forests stood compared to deforested areas (Kathiresan and Rajendran, 2005). Displacement due to shocks is usually, however, short-term and short-distance, with most people returning to their home as soon as ecosystem services recover and livelihoods are viable (Black et al., 2013).

Changes in ecosystem services alter the relative advantages and disadvantages of areas for in- and out-migration. Given current global environmental change trends, the influence of ecosystem service status on migration is expected to increase in the future (Black et al., 2011). In drylands, for example, residents may choose to leave as land degradation causes loss of soil nutrients, food and water for humans and livestock. Indeed, de Sherbinin et al. (2012) found that the most dominant source of out-migration in developing countries between 1970 and 2000 was from marginal drylands and drought-prone regions. Small island states threatened by sea level rise and regions affected by increasingly frequent and severe climate hazards are also often cited as potential places from which international migration will increase (de Sherbinin et al., 2012).

Environmental risks and degraded regulating ecosystem services contribute to involuntary migration through a number of intervening variables. First, migration is driven by multiple, interacting political, social, economic, demographic and environmental signals, such as resource scarcity, which interact in multi-causal ways. Attributing migration to environmental dimensions is therefore neither possible, nor fruitful (Black et al., 2011; Renaud et al., 2011). Second, empirical studies of climate-related hazards and other environmental drivers have shown both increasing and decreasing migration outcomes (Table 5.1). Land degradation, for example, triggered migration in cases in Kenya and Guatemala but reduced human mobility in cases in Uganda and Mali. The examples in Table 5.1 also demonstrate that migration can decrease among some groups in the population and increase among others concurrently: migration outcomes vary within localities, differentiated by gender, class and income. In effect, migration is a household-level strategy for spreading risk and gaining income and resources: environmental shocks therefore act to dampen and reduce opportunities for migration as a livelihood strategy (Adger et al., 2002; Call et al., 2017).

Vulnerability to environmental risks and mobility have been shown to have an inverse relationship: those that are most vulnerable to environmental change have the least resources to migrate to less exposed sites (Black et al., 2013). Ecosystem service loss may reduce the resources available for vulnerable populations to move, while those with the means migrate, temporarily or permanently, to areas with more favourable ecosystem service availability. Some empirical studies support this perspective. Call et al. (2017), for example, found that environmental variability observed in Bangladesh over two decades disrupted livelihood mobility rather than displaced people (Table 5.1).

The increasing influence of environmental drivers on migration decisions means that ecosystem management has the potential to play an important role in amplifying or dampening migration. Policies and interventions aimed at addressing or reducing vulnerability to environmental change may maintain ecosystem services and wellbeing in an area and therefore discourage migration. Mangrove planting, for example, can reduce exposure to storms and tidal surges and therefore reduce the risk of displacement. Given the complex interaction between human and environment factors in determining migration trends, an ecosystem service lens may offer

TABLE 5.1 Migration outcomes of ecosystem service losses and environmental shocks

Location	*Environmental shock or change*	*Key ecosystem service effects*	*Impact on migration*	
Vietnam (Dun, 2011)	Increasing frequency of extreme **floods** events	Destruction of crops	↑	Triggered household or individual migration
Ethiopia (Gray and Mueller, 2012)	**Drought**	Loss of livestock and crops	↑	Men's labour migration more than doubled under severe drought as a coping strategy
			↓	Female marriage migration decreased by half under moderate drought, reflecting decreased ability to finance wedding
Bangladesh (Call et al., 2017)	**Precipitation, temperature** and **flooding** variability	Destruction of crops and reduced productivity	↓	Floods decreased temporary migration in aftermath
			↓	Persistent heavy precipitation decreased migration
			↑	Increased temperatures increased temporary migration
Kenya and Uganda (Gray, 2011)	**Soil degradation**	Reduced soil quality	↓	Significantly reduced migration in Kenya
			↑	Marginally increased migration in Uganda
Bangladesh (Paul, 2005)	**Tornado**	Loss of crops and cattle	—	No migration due to distribution of disaster relief
Ghana (van der Geest, 2011)	**Drought and slow onset environmental degradation**	Soil fertility	↓	During worst droughts of late 1970s and early 1980s, migration decreased
			↑	Increased out-migration due to push of land scarcity and soil infertility and, more importantly, pull of fertile land

new insights on the role of environmental factors in pushing and pulling people to migrate. At the same time, if migration and vulnerability are inverse, common property institutions may inadvertently contribute to trapping vulnerable populations by inhibiting mobility.

Wider population dynamics and ecosystem services

Migration and mobility are part of wider demographic transitions and population dynamics. While migration alters the spatial pattern of population density, it is also embedded in demographic trajectories: migration rates are partly determined by the availability of working-age individuals, dependency ratios and resource pressures (Hugo, 2011). Hence, resource pressure, through demand for provisioning ecosystem services and impacts on regulating ecosystem services, is related to population density or other elements of population structure. There are several population structure factors that affect ecosystem services, resource demand and their locally dependent population: age profile, household size and dependency ratios. Changing demographic structures have profound effects on ecosystem services (Liu et al., 2003).

Demand for provisioning ecosystem services changes over the life course, with peak consumption typically correlated with periods when individuals are at lifetime peak income levels. The single most significant demographic factor for burdens on ecosystem services, however, is the observed reduction of average household size in virtually all regions of the world. Liu et al. (2003), for example, showed that countries with biodiversity hotspots had higher levels of household formation (i.e. the same population but living in smaller-sized households) in the 15 years to 2000, which increased urban sprawl and pressures on biodiversity. Similarly, Kaye et al. (2006) show that small household size directly affects biogeochemical flows and pollution loading, and Cardillo et al. (2004) argue that population density is a factor in localised extinctions of carnivore populations. Hence, the structure of populations has interacting effects with ecosystem services.

Ecosystem services and demographic change further interact through how economic security facilitates or stalls demographic transitions. There is a well-recognised link between poverty and fertility choice, but with scattered evidence of the causal nature of relationships: for example, in the relationship between increased insecurity associated with environmental decline and high fertility rates. López-Carr and Burgdorfer (2013), for example, observed high levels of fertility in remote forest frontier environments in Latin America caused by economic insecurity. The general evidence on fertility shows that drivers of higher than replacement fertility levels in societies are around social conformity and expectations on one hand and economic drivers, such as economic or environmental insecurity, on the other. The impact of ecosystem service decline and accessibility on fertility remains indeterminate, but most theory and empirical evidence points to how ecosystem service decline potentially leads to livelihood insecurity in disadvantaged populations (Daw et al., 2011), and such insecurity potentially stalls poverty alleviation, with knock-on effects on migration, fertility choice and other human responses.

Frontiers of research on migration, mobility and population dynamics

The interactions between ecosystem services, migration and wider demographic trends are highly complex and dynamic, and ecosystem services are more usefully viewed in terms of social-ecological systems rather than static resources in terrestrial landscapes. Migration systems have indeed their own dynamics, and while environmental change and risks influence the main drivers of migration, movement continues despite environmental risks in both source and destination areas. Insights into migratory flows, population dynamics and resource pressures point to three emerging scientific frontiers on ecosystem services, migration and population dynamics.

First, the major demographic transitions under way around the world mean ageing populations, larger urban populations and different relationships between urban and non-built landscapes everywhere. Cities are becoming denser in some areas, and more extensive in others: but everywhere they are drawing on wider ranges of ecosystem services and have evolving links to hinterlands and global economic markets (Seto et al., 2012; Marshall et al., this volume). In this global context, the provision of urban ecosystem services is the critical challenge for cities, as recognised within city plans and international initiatives up to the urban Sustainable Development Goal. Migration, rather than natural population growth, drives the expansion of cities in Asia and Africa in particular. In these contexts, the ability of new migrant populations to access safe environments, clean water and green spaces has been shown to be critical to their wellbeing, and to making migration a sustainable route out of poverty (Roy et al., 2016). How ecosystem services can be managed for urban expansion through green infrastructure and other routes, and the role of technology in providing nature experiences to urban residents, for example, is a critical research arena.

Second, ecosystem services remain critical for pathways out of poverty and for influencing why populations persist in environments where there are incentives for depopulation, not least marginal agricultural areas. de Sherbinin et al. (2012) showed how, globally, 50–100 million people migrated from each of mountain and dryland regions between 1970 and 2000. Populations persist in these regions, in part, because of the value of ecosystem services to those populations, not least in their sense of place and cultural importance (Adams, 2016). Thus, research on how ecosystem services interact with long-term population movements, and the value of regulating services in avoiding involuntary migration, is a further research frontier.

Third, the evidence in this area suggests that many interventions for management of ecosystem services may be challenged because they fail to account for mobility, both of ecosystem processes and the distributions of populations accessing them.

These challenges have already been noted, for example in terms of the telecoupling of cause and consequence of actions and ecosystem processes (Pascual et al., 2017; Rieb et al., 2017). But further, increasing mobility may challenge traditional collective action and co-management of ecosystems: as people move in and out of areas, the boundaries of communities, users and resources are tested and breached. Hence migration and population dynamics are a key challenge for ecosystem service science: it needs to embrace the full spectrum of relevant social sciences, from demography to the sociology and human geography of place.

Acknowledgements

This chapter draws on research under Assessing Health, Livelihoods, Ecosystem Services and Poverty Alleviation in Populous Deltas (NERC Grant No. NE/J000892/1), part of the Ecosystem Services for Poverty Alleviation programme; and on Deltas, Vulnerability and Climate Change: Migration and Adaptation project (IDRC 107642) under the Collaborative Adaptation Research Initiative in Africa and Asia Programme, with financial support from the UK Government's Department for International Development and the International Development Research Centre, Canada. We thank Helen Adams and the editors for constructive comments. This version remains solely our responsibility.

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