The Pennsylvania State University

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HOME GARDENS AS AGROBIODIVERSITY SITES AMID AGRARIAN TRANSFORMATIONS IN JEJU, KOREA (1960–2016)

A Dissertation in

Geography

by

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ABSTRACT

Geographic research has focused on identifying spaces of agrobiodiversity amid rural changes that may threaten continued cultivation and the future of farmer-based evolution. This dissertation investigates home gardens as important agrobiodiversity sites in rural Jeju, South Korea, where land and livelihoods have been fundamentally transformed over the past few decades as a result of widespread adoption of commercial cropping and livelihood diversification associated with agricultural modernization and tourism development. The dissertation draws upon and contributes to geographic literature in three broad areas: the environment–society geographical investigations of home gardens as agrobiodiversity sites, the political ecology investigation of the state's role in agrarian development and modernization, and geographies of agrarian transformations, especially agricultural commercialization and livelihood diversification. The findings demonstrate how local people have re-configured home garden agrobiodiversity in response to agrarian changes. The research also tests several environment–society hypotheses currently under debate regarding factors influencing home garden cultivation practice and agrobiodiversity.

Three broad sets of questions guide the dissertation's research. These are: (1) which types and categories of plants are cultivated in contemporary rural home gardens (in 2015), and which household and community factors, especially those related to the locale's diversified livelihoods, influence the plant diversity and composition of home gardens? (Chapter 2); (2) how did farmers use home gardens as agrobiodiversity sites amid state-led agricultural commercialization and adoption of improved crops and crop varieties (1960–1980), and what do the uses of home gardens reveal about the opportunities and risks that such agrarian transformations presented to smallholders? (Chapter 3); and (3) how do agrarian transformations (agricultural commercialization and livelihood diversification) affect the local land use and land cover, and

how do local people adapt to the changes in terms of ethnobotanical plant use (1972–2016)? (Chapter 4).

The dissertation has three major findings. First, despite the challenges posed by agricultural commercialization and livelihood diversification, Jeju home gardens have maintained their identities as food and medicinal plant production sites. Their provisioning function continues to be important for a portion of the population, including geographically isolated communities and older people. Second, the successful adoption of citrus as a cash crop was facilitated by the crop's high spatial compatibility with the local farming system. This compatibility resulted from an interplay between the availability of marginal lands in the farming system, the region-specific state interventions that were supportive of farmer autonomy, and crop characteristics, rather than the inherent trait of a crop alone. Third, the home gardens functioned as a refuge site for wild plants perceived to have become unavailable in the wild but with value to local people. Such wild plant incorporation in home gardens was more prominent in villages with a higher proportion of wild and semi-wild land cover, indicating that such villages allow greater human–nature engagement, ensuring the continuity and spread of knowledge and value of the plants among the locals.

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Chapter 1

Introduction to home garden agrobiodiversity, role of the South Korean state in agricultural development, and agrarian transitions

1.1 Introduction and overview: Smallholder agriculture, agrobiodiversity, and home gardens amid improved crop adoption and livelihood diversification since the 1960s

Agrobiodiversity, which is defined as the biodiversity of food and agriculture (CBD 2000; FAO 2019; Zimmerer et al. 2019), contributes to global food production and the environmental and social sustainability of food and agricultural systems (FAO 2010; Johns et al. 2013; Zimmerer and Haan 2019; Zimmerer et al. 2019). Diversity of crops and crop varieties, a component of agrobiodiversity, has been developed and managed primarily by smallholders (Bellon 1996; Brookfield 2001; Brush 2004), who are defined as cultivators and resource users whose capital and land allocations (typically less than 2 ha; HLPE 2013) are relatively small (Netting 1993; Zimmerer, Lambin, and Vanek 2018). However, the large-scale adoption of scientifically bred crops and crop varieties, which is frequently encouraged by governments and international agencies to achieve food production growth, often displaces traditional crops and varieties that have long been cultivated by smallholder farmers (Pretty 1995), causing loss of genetic variation (Harlan 1975; van de Wouw et al. 2010; Anderman et al. 2014). The local consequences often include stagnant or declining well-being of smallholder farmers to whom agrobiodiverse farming has offered food and livelihood security (Thrupp 2000; Perreault 2005; FAO 2019).

This dissertation draws upon the work of geographers and scholars of cognate disciplines who have challenged and enriched the narrative of complete or unilinear displacement of agrobiodiversity (Zimmerer 1996; Louette, Charrier, and Berthaud 1997; Cleveland, Soleri, and Smith 2000; Brookfield 2001; Abbott 2005; Oakley and Momsen 2005; Olson, Morris, and Méndez 2012). Traditional and modern crops and varieties often coexist in local landscapes, occupying different socio-cultural, economic, and environmental niches (Abbott 2005; Bellon and Hellin 2011; Keleman, Hellin, and Flores 2013; Steward 2013; Zimmerer 2013; Turner and Davidson-Hunt 2016). The goal of this research is to advance sustainable development involving biodiversity and food security by increasing the understanding of how local people manage and reconfigure agrobiodiversity amid land and livelihood changes.

Home gardens, adaptable and accessible sites for plant cultivation (Buchmann 2009), are an example of spatial niches that can conserve dwindling agrobiodiversity (Galluzzi, Eyzaguirre, and Negri 2010). The home garden is defined as an area adjacent to a house where household members manage crops and other plants, and often raise animals, of value to the household (Kimber 2004; Kumar and Nair 2004). Home gardens are not isolated systems but instead constitute an important node in the network of sites in agricultural landscapes in which wild and domesticated plants are managed (Casas et al. 1996; Ban and Coomes 2004; Steward 2013). They serve as valuable reserves of agro- and wild biodiversity (Galluzzi, Eyzaguirre, and Negri 2010). These roles of home gardens are particularly important amid transformations of the landscape that pose challenges to continued cultivation and exploitation of crops and other useful plants in the surrounding lands. These transformations include agricultural commercialization, deforestation, and loss of fields and fallows that accompany new land development (Rerkasem et al. 2009; Cruz-Garcia and Price 2014; Heraty and Ellstrand 2016; Cruz-Garcia 2017).

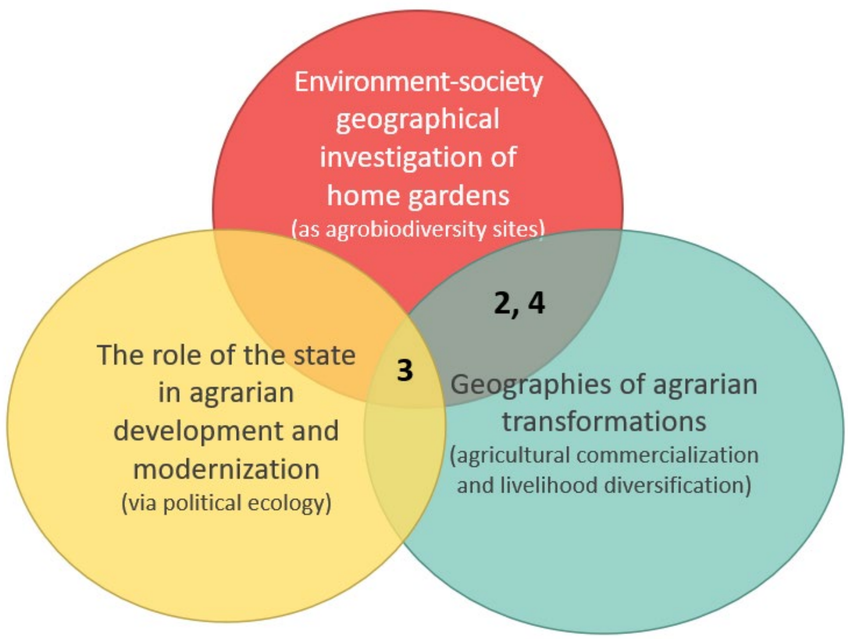
The twentieth-century state became an important initiator and promotor of continued agricultural modernization and rural development, which have impacted agrobiodiversity (Abbott 2005; Bellon and Hellin 2011). The state's motives and ability to achieve the true well-being of rural people have been recognized as flawed in critiques by scholars in political ecology and cognate fields (Ferguson 1994; Vandergeest and Peluso 1995; Scott 1998; Li 2007; Neumann 2014). However, the state can pursue either benevolent or "wicked" agricultural and agrobiodiversity policies (Longhurst 1988), and it can have different state development visions for different subnational regions (de L.T. Oliveira 2013), both of which can vitally affect development outcomes. Smallholder farmers also appeal, negotiate, and resist state-initiated actions (Zimmerer 1991; Muldavin 1997; Turner 2012).The state may also foster favorable conditions for smallholder endeavors; for example, it can support both retention of landraces[1] (Bellon and Hellin 2011) and smallholder-initiated entrepreneurial projects (Cramb and Curry 2012).

This dissertation begins by investigating the contemporary and historical roles of home gardens amid various processes that transform the context of plant cultivation in rural home gardens and may threaten continued use and management of agrobiodiversity (including that of useful wild plants) in and around home gardens. To this end, this dissertation addresses three

[1] Landraces or farmer varieties are defined as crop varieties that have been cultivated in the farming system for a relatively long period (e.g., more than one generation) and that are farmer-selected and often adapted to the local environment (Harlan 1975; Zeven 1998; Cleveland, Soleri, and Smith 2000; Villa et al. 2005; Zimmerer 2010a; Calvet-Mir et al. 2011).

related questions: What plants are cultivated in contemporary rural home gardens, and what household and community factors, especially those related to the locale's diversified livelihoods, influence the plant diversity and composition of home gardens? (Chapter 2). How did farmers use home gardens as agrobiodiversity sites amid state-led agricultural commercialization and adoption of improved crops and crop varieties, and what do the uses of home gardens reveal about the opportunities and risks that such agrarian transformations presented to smallholders? (Chapter 3). How do agrarian transformations (agricultural commercialization and livelihood diversification) affect the local land use and land cover, and how do local people adapt to the changes in terms of ethnobotanical plant use? (Chapter 4).

1.2 Themes addressed in this dissertation and related geographical literature



Chapter 2: Cultivated plant diversity in home gardens of Jeju, South Korea, and its determinants amid pronounced livelihood diversification

Chapter 3: Regionally divergent roles of the South Korean state in adopting improved crop varieties and commercializing agriculture (1960–1980): A case study of areas in Jeju and Jeollanamdo

Chapter 4: Useful plants from the wild to home gardens: Testing an ethnobotanical hypothesis in the changing land and livelihoods of Jeju Province, South Korea

Figure 1.1: Chapters of the dissertation in relation to relevant geographic subfields

To address the three core questions, I draw on concepts from three broad subfields of geography and cognate fields (Figure 1.1): environment-society geographical investigation of home gardens (as agrobiodiversity sites); the role of the state in agrarian development and modernization (via political ecology); and the geographies of agrarian transformations (specifically, agricultural commercialization and livelihood diversification). Figure 1.1 situates the chapters of this dissertation in relationship to these subfields (see section 1.7 for an introduction to each chapter).

Geographers in the environment-society subfield have paid considerable attention to vernacular gardens as cultural ecological expressions, as opposed to high-style gardens, and the relationship between the garden-tending household, wider community, and garden and its components (Doolittle 2004; Kimber 2004). In particular, geographers have focused on the biological and cultural aspects of home gardens, including their agrobiodiversity. Studies have elucidated the roles of planting material exchange in maintaining home garden agrobiodiversity and the garden tenders' social networks (Ban and Coomes 2004; Abizaid, Coomes, and Perrault-Archambault 2016) and the role of the home garden space and production in cultural reproduction of nature-society relations (Christie 2004; Perreault 2005), and analyzed the dominant role of women in home garden tending as a partitioning of productive landscapes by gender (e.g., crop fields and home gardens are tended primarily by men and women, respectively) (Oakley and Momsen 2005).

More recently, the home garden has attracted renewed attention in environment-society geography as a part of urban agriculture (WinklerPrins 2017; Zimmerer et al. 2021) and an alternative space for food production (WinklerPrins and Oliveira 2010; Kortright and Wakefield 2011; Gray et al 2014). However, there has been little research in geography or other fields on home garden agrobiodiversity in the non-Western part of the Global North, such as East Asia, except for a few newer studies by researchers from cognate fields (Clarke et al. 2014; Kamiyama et al. 2016), although the region's home gardens are important sites of agrobiodiversity, as the commercial agriculture in the region relies heavily on scientifically bred crops and crop varieties.

Geographers have extensively studied the role of the state in agrarian development and how it affects the development processes and outcomes in local contexts (Watts and Bassett 1986; Zimmerer 1991; Carney 1993; Keleman, Hellin, and Bellon 2009; Clay 2017). In geographers' understanding of the interdisciplinary approach of political ecology, the state has generally been assigned great importance as playing a key role in the unfolding of a study site's environment-society relations (Blaikie and Brookfield 1987; Robbins 2008; Harris 2017; Loftus 2020). Although state interventions in development have generally been viewed as negative in the literature (Ferguson 1994; Scott 1998; Li 2007), geographers have analyzed state-nature relations as complex and unevenly developed in various social and environmental contexts (Robbins 2008). Specifically, geographical analyses have elucidated how local people accommodate, resist, or negotiate different elements of state projects, such as improved crop introduction, according to their socioeconomic and agroecological circumstances (Turner 2012; Clay 2017), and how new agro-technologies are received differently according to place-based characteristics such as the importance of cash income in local livelihoods (Basu 2009).

In East Asia, the state-nature relations of the Chinese state have been relatively well-studied by geographers (Muldavin 1997; Wang 2006). However, the political economic trajectories of other newly industrialized countries (NICs) of East Asia, such as South Korea and Taiwan, have differed profoundly from that of communist China (Looney 2012) and thus deserve individual and contextualized attention. NICs with a strong paternalistic role in development, the so-called developmental states (Woo-Cumings 1999), have been studied by geographers (e.g., Lee and Tee 2009; J. T. Hwang 2016; Hsu 2017). However, geographical investigations of developmental states have considered mainly the state's role in industrial development, and the spatial focus has typically been metropolitan cities. The Korean state's historically strong involvement in rural and agricultural development has recently started to attract the attention of geographers (Doucette and Müller 2016; Jeong 2017), but their focus has been state-society relations, rather than the association of these relations with biophysical realities and their differential development according to local social and biophysical conditions.

Another theme relevant to this dissertation is the geographies of agrarian transformations, including agricultural commercialization and rural livelihood diversification, as a part of de-agrarianization, especially as they pertain to its impact on local agrobiodiversity. Programs to promote agricultural commercialization to increase food production and rural income often directly dictate or incentivize certain crop choices, specifically crops with high commercial value, which often contributes to increased food production but creates new vulnerabilities, resulting in a mixed reception among farmers (Turner 2012; Clay 2017). Resource and infrastructural development to increase commercial food production, such as the development of irrigation, may alter rural land use and the agrobiodiversity of uncultivated plants, which, in turn, affects the agrobiodiversity of cultivated plants (Zimmerer 2010b). Among the livelihood options available to them, farm households develop strategies that combine various options (e.g., farm and non-farm work) to achieve food security and meet other needs and desires (Nyantakyi-Frimpong 2017; Manda, Tallontire, and Dougill 2018).

As a result of the preceding processes, livelihood diversification is often intertwined with labor-related migration, which alters the sociopolitical and resource dynamics of households and communities at the origin and destination points (Hecht 2010; Knudsen and Agergaard 2015; Sunam, Barney, and McCarthy 2021), driving land use and land cover changes ranging from intensified cash cropping to forest resurgence (Hecht 2010; Rungmanee 2014) and affecting the environment in which local landrace agrobiodiversity is maintained (Zimmerer 2014). The impact of home garden agrobiodiversity is not uniform: State-led de-agrarianization in resource-scarce areas (e.g., areas where agricultural water is scarce) may cause farmers to adopt home garden plant cultivation, which is less resource-intensive, instead of field agriculture (Connor and Mtwana 2018). However, the availability of non-farm income may also decrease household reliance on subsistence agriculture, including home gardens (Louis 2015), and take time and other resources away from home garden plant cultivation (Pritchard et al. 2019). Rural-to-urban migration may create networks linking urban and rural households that are strengthened by home garden plants and planting materials, and thus facilitate the survival of rural-to-urban migrants (WinklerPrins and Oliveira 2010).

This dissertation contributes to the geographical literature, especially discussions pertaining to the environment-society relations concerning rural development, natural resource management, and the role of the state in these activities. Rather than viewing the state as uniformly self-serving or incompetent, the study investigates the multifaceted roles of the Korean state in improved crop adoption and agricultural commercialization, which vary among subnational regions. The development efforts and outcomes of the Korean state lie within the broader political economic context to avoid "rendering technical" (Doucette and Müller 2016) some of the state's apparent developmental success and indiscriminately making the successful cases a development role model for the currently developing part of the world. This study also investigates local participation in and responses to agrarian transitions and related land, livelihood, and lifestyle changes, which may require a spatial reconfiguration of agro- and wild biodiversity. Among these responses, local people use home gardens in the area of the case study of Jeju Island, Korea (introduced below in Section 1.5), to both embrace new entrepreneurial opportunities [e.g., high-return tangerine (citrus hereinafter) production] and conserve useful wild plants whose populations are threatened in the wild. The study also contributes to the geographical and ethnobotanical literature by providing inventory data on home garden plants and analyses of the cultivated plant diversity and composition in home gardens and its geographic distribution, as well as the livelihood, demographic, and biophysical determinants of agrobiodiversity. Rather than merely describing the local cultivated flora, the study analyzes human (livelihood, demography) and biophysical (soils, climate, and elevation) factors that may affect home garden agrobiodiversity, and thus the requirements and resources for home garden plant cultivation.

An environment-society hypothesis centered on current debate in ethnobotany is tested in Chapter 4 to investigate whether the wild land cover (a potential plant harvesting site and planting material source) of surrounding lands affects plant diversity in home gardens. In addition, the study is conducted in East Asia, where there has been almost no ethnobotanical or geographical investigation of cultivated plants in home gardens, although the region's culture has been classified as herbophilic (herb-liking), and the consumption of green vegetables, as well as other food and medicinal plants, remains highly popular (Łuczaj 2010), as are the gathering and cultivation of useful plants (Pemberton and Lee 1996). Additionally, until recently, geographers have rarely studied the theme of *in situ* agrobiodiversity in industrialized East Asia, let alone the agrobiodiversity of home gardens. This study marks the first geographic study of *in situ* agrobiodiversity in Korea, and possibly in East Asia. In addition, the region's rural development and agrarian transformations have insufficiently received geographic attention. This dissertation investigates the unique role of one of the developmental states in rural development in the environment-society tradition in geography, taking account of the region's unique state-society relations and the impact on farmer-held agrobiodiversity and general agrarian development.

1.3 Structure of this dissertation

There are three empirical chapters in this dissertation (Chapters 2–4) in addition to the introductory chapter (this chapter) and the concluding chapter. The empirical chapters are written as independent articles for publication in peer-reviewed journals. Thus, each has a stand-alone structure, including an introduction, literature review, introduction of the study area (sites) and methods, and a conclusion. Chapter 2 is intended for publication in *Economic Botany* or *GeoJournal*, Chapter 3 is written for *Annals of the American Association of Geographers* or *Agriculture and Human Values*, and Chapter 4 is intended for publication in *Journal of Ethnobiology*. The author of the dissertation (Yooinn Hong) will be the sole author of the papers based on Chapters 2 and 3, whereas the authorship of the paper from Chapter 4 will be shared between Yooinn Hong and her doctoral adviser, Karl Zimmerer.

The first chapter provides a general introduction to the dissertation, giving an overview of the research questions that Chapters 2–4 address and the methods employed to answer them. This chapter also introduces readers to each of the empirical chapters. Chapter 5 summarizes key findings from the empirical chapters and suggests directions for future research.

1.4 Research objectives and questions

This dissertation investigates agro- and wild biodiversity in the home gardens of Jeju, South Korea, and situates home garden plant cultivation practices in the context of historical changes to the local land, livelihoods, and demography (1960–2015). By examining this topic, I reveal the general state of *in situ* agrobiodiversity management in the locale and the roles of home garden plant cultivation in agrobiodiversity conservation in the Jeju region and the local livelihoods. The spatial focus of the dissertation is the region's rural and semi-rural home gardens as agrobiodiversity sites, as they are frequently the most agrobiodiverse sites that a rural household manages, and they are often the only subsistence component in Jeju agriculture, which is highly commercialized. The dissertation regards home gardens as nodes in a network of agrobiodiversity sites in the rural landscape in which planting materials are exchanged with various plant habitats in the landscape matrix (e.g., agricultural lands, forests), rather than as isolated "islands" in a sea of non-habitats, to borrow a concept from island biogeography (MacArthur and Wilson 1967). The study analyzes agricultural commercialization and improved crop adoption in Jeju (1960–1980) and livelihood diversification (1980–) as processes that profoundly changed the land, livelihoods, and demography of the region and thus affect the requirements and resources for home garden cultivation. Chapter 3 compares the processes of agricultural commercialization and improved crop adoption with the improved rice variety adoption in rice-growing regions of mainland Korea in the 1970s in terms of the roles of the state and smallholders and the crop-specific traits that influenced the adoption.

The objectives and questions in Table 1.1 structure the work of this dissertation and address the three core questions presented in Section 1.1

Table 1.1: Objectives of each chapter and the corresponding questions

Objectives	Questions
Chapter 2: Identify which plants are cultivated in contemporary rural home gardens and which factors, especially those related to diversified livelihoods, influence the plant diversity and composition of home gardens.	a. What plants are cultivated in home gardens. and how diverse are the plant species (taxa)? b. Which demographic is likely to cultivate plants in home gardens, and which cultivates a larger number of diverse plants? c. What geographic factors (e.g., soil, elevation) affect home garden plant diversity or composition in Jeju?
Chapter 3: Determine how farmers use home gardens as agrobiodiversity sites amid state-led agricultural commercialization and adoption of improved crops and crop varieties, and what the uses of home gardens reveal about the opportunities and risks that such agrarian transformations present to smallholders.	a. How did adoption of improved citrus cultivation occur in Jeju? b. What resources did farmers need for adoption of improved citrus cultivation, including spaces for citrus cultivation, and how were the resources provided? What was the role of the state in the adoption and provision of resources? c. What were the local and political economic factors that differentiated the outcome from that of the Korean Green Revolution in rice, which occurred around the same time?
Chapter 4: Determine how agrarian transformations (agricultural commercialization and livelihood diversification) affect local land use and land cover and how local people adapt to these changes in terms of ethnobotanical plant use.	a. Which and how many wild plant taxa occupy home garden plant inventories, and what are the plants' uses? How many of the local useful wild plants are found in home gardens? b. What is the relationship between home garden wild plant diversity and the forest cover of the surrounding land? c. What land, livelihood, and demographic changes have affected wild plant availability and accessibility in the surrounding land? How do home garden tenders respond to these changes?

1.5 Case study focus

Jeju Special Self-Governing Province (Jeju Province hereafter)

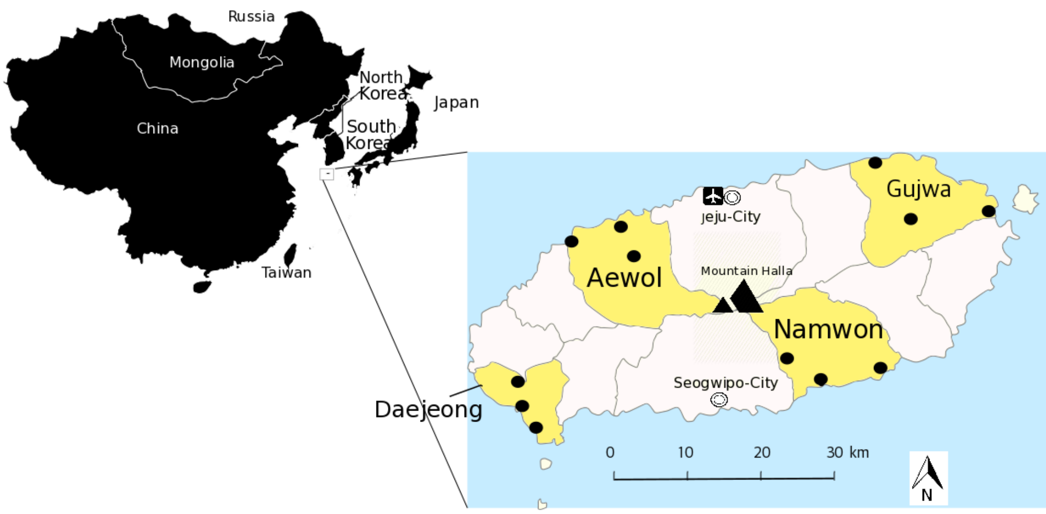


Image sources: (left) Zuanzuanfuwa (2009), (right) modified from Asfreeas (2011)

Figure 1.2: Map of Jeju Province and locations of 12 study villages (filled dots on the map) within four study subregions (Aewol, Gujwa, Daejeong, Namwon; yellow regions in the map)

The dissertation study was conducted in 12 villages in four subregions across Jeju Province, South Korea (Figure 1.2). The province has been quite distinct from the other eight provinces of South Korea. First, it is not part of the Korean Peninsula but consists of an island of 1,833 km^2 and much smaller islands. The volcanic soils of the island have also influenced its unique traditional cropping systems, which include grains and legumes that require less water, such as barley, millet, soy, and upland rice. Because paddy rice cannot be grown in the region, the province did not have to participate in the nationwide drive to increase rice production by adopting high-yielding rice in the 1970s. (Chapter 3 compares the adoption of improved varieties of citrus in Jeju with the high-yielding rice adoption in mainland rice-growing regions using a reference county, Jangseong County, Jeollanamdo Province.) The climate of Jeju is also generally the warmest in Korea, enabling the cultivation of unique warm-weather crops that provide high commercial returns (e.g., *unshiu* citrus). Its geographic isolation from the mainland has produced unique flora, fauna, and human culture, including extensive ethnobotanical knowledge among the people of Jeju, which balances their poor access to resources (Kim, Jeong, and Kang 2015). The province gained international recognition for its biodiversity when it became one of the first biosphere reserves in South Korea (Jeju Island Biosphere Reserve) in 2002.

As a "rural miracle" that transitioned from one of the poorest rural regions of the country to the wealthiest, the province represents a locale that underwent economically successful agricultural commercialization and greatly decreased its reliance on subsistence agriculture. The most notable agrarian transformations the region experienced were the successful introduction of cash crops (beginning in 1960) and livelihood diversification related to tourism development (beginning in 1980), which increased both farm and non-farm income. Although the higher income helped limit the migration of young people to cities in mainland Korea, rural Jeju has still lost much of its farming population (67% of all Jeju households were farm households in 1970, and only 15% were in 2015). Additionally, Jeju has held an image of a "clean Jeju" to the outer world. "Clearn Jeju" became an official motto to promote Jeju tourism by the provincial government. Of seven administrative provinces of South Korea, Jeju has had the weakest developed manufacturing industries (3.8% contribution to Gross Regional Domestic Product as of 2015), while most other provinces experienced industrialization-led economic growth.

The lack of industrial development in Jeju was beneficial for the tourist industry in the region by leaving the environment relatively unpolluted. Combined with volcanic terrain, these forces that helped keep undeveloped much of the island, which became known as an idyllic tourist location endowed with unpolluted and rich natural settings. With the help of such images as "clean Jeju," the island has attracted a large influx of tourists (15 million visitors annually as of 2016) and amenity migrants, changing the livelihood and demography of the island. The site-relevant questions are as follows: What is the status of cultivated plants in Jeju home gardens considering that people now have other means of obtaining food and livelihood necessities owing to increased farm and non-farm income? What land, livelihood, and lifestyles changes did local people experience during the two processes, and how did they participate in and respond to the changes? How did people use home gardens as agrobiodiversity sites?

1.6 Methodological overview

Overarching research design

Figure 1.3 shows the research design of this dissertation. The blue boxes show the core analyses, and the corresponding chapters are identified. Home garden visits (plant inventories and garden tender interviews) provided the core data for the analyses in Chapters 2 and 4 and motivated the studies in Chapters 3 and 4. The plant inventory data were used primarily for Chapter 2 (ANOVA, ordination and regression analyses) and Chapter 4 (regression of home garden plant diversity on land cover type). The plant list was compared with other lists of plants of value to humans (ethnobotanical plants; Kim, Jeong, and Kang 2015), briefly in Chapter 2 and in detail in Chapter 4. Then follow-up focus groups and interviews were conducted in 2016 to answer the research questions of Chapters 3 and 4. To study the impacts of demographic, livelihood, and biophysical variations on the agrobiodiversity in home gardens in Jeju (Chapter 2), a cross-sectional and crossed (four subregions × three villages) study design was created. The study investigated the agrobiodiversity in sample home gardens (n = 131) in 12 villages, which were assigned to four selected subregions of Jeju (Figure 1.2.). The four subregions represent high-level biophysical variations in climate and soil that have traditionally provided limitations and opportunities for agriculture in Jeju. In addition, three villages per subregion were selected to represent variations in elevation and level of development within subregions. For convenience, villages were classified as A (coastal villages with more developed and urbanized land), B (coastal villages with less developed land), and C (mid-hill villages). The villages differed significantly in elevation (A, B–C), population density, and the possession of urban or commercial infrastructure (A–B, C).

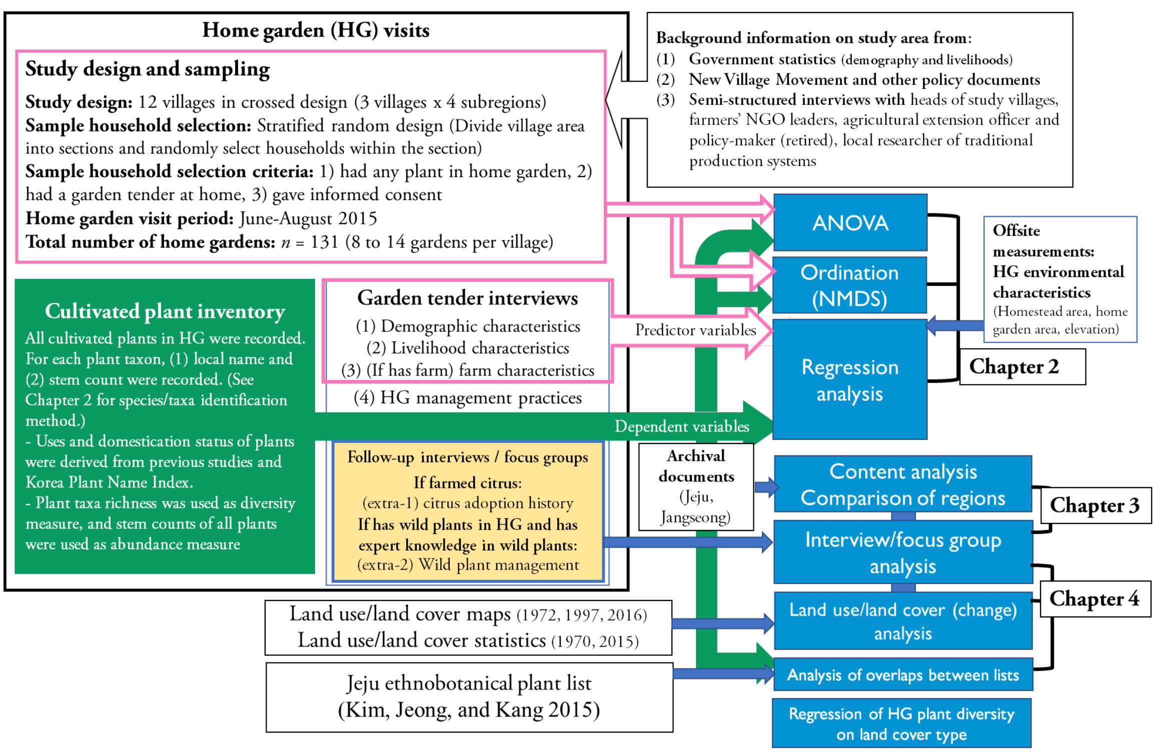


Figure 1.3: Research design showing data and analytic methods used in this dissertation

Home garden visits and sampling

In each of the 12 villages, 8–14 households were randomly selected for home garden visits in June–August 2015. The gathered data were used in all empirical chapters, especially serving as core data in Chapters 2 and 4. Each selected household had to meet following three criteria: 1) it had cultivated plants in home gardens, 2) at least one garden tender was at home at the time of the visit, and 3) this person was able to grant informed consent. If the household met the criteria, the author performed two tasks during the visit. The first task was to identify all plant species (taxa) and count the stems of all individual plants under cultivation in the home garden. Species were identified by the local name provided by the garden tender. Significant varietal variations (e.g., broccoli, kale, and cabbage in the species *Brassica oleracea*) were recognized as different taxa. The second task was to ask the garden tender(s) to provide information on the household's demography, livelihoods (including farm characteristics, if the household farmed), and management of the home garden. The author added physical information about the house and home garden, specifically, the home garden area, homestead area, and elevation, using online services (area information from http://local.daum.net and elevation data from https://www.freemaptools.com/elevation-finder.htm).

Chapter 2: Data analysis (ANOVA, ordination, and regression)

The statistics on plant taxa richness and composition in all the sample gardens were compared, and one-way analysis of variance (ANOVA) and Tukey–Kramer HSD tests were performed to examine whether the selected geographical divisions differ significantly in the diversity and abundance of cultivated plants; the details are given in Chapter 2. The geographical divisions were individual villages, subregions, north–south, east–west, and village types A–C. Additionally, the taxon compositions of the home garden plants were analyzed using an ordination analysis (by abundance) to investigate potential differences by village, subregion, the north–south and east–west divisions, and village types A–C. Non-metric multidimensional scaling (NMDS) using the Bray–Curtis distance measure was applied.

To determine household-level factors that may affect the plant diversity of home gardens, two sets of stepwise multiple regression analyses were performed. Two regression models were established to include two sets of independent variables, one for all households and the other for only farm households. The two-model approach was necessary as the farm households were asked additional questions to specify the characteristics of their farms (e.g., a list of field crops), which produced an additional set of independent variables.

Chapter 3: Data collection and analysis (content analysis, comparison of regions, interviews and focus group)

Chapter 3 details the current cultivation information and household histories of citrus adoption that were collected from the subset of n = 131 home gardens with citrus production (n = 41). Some of the 41 households gave more detailed information on adoption of improved citrus cultivation at the household level, and a full focus group interview (oral history) on the village-level improved citrus adoption history was conducted through focus group interviews with the village elders of Wimi-1 village. In addition, this chapter presents the analyses of archival documents consisting of success case stories of improved citrus adoption in Jeju from yearly government reports (n = 11 documents) summarizing annual achievements during the New Village Movement (NVM; Saemaeul Undong). The NVM is a state-led modernization campaign that was most active in the 1970s; its main purpose at that time was to modernize rural people's "backward mindset" and the rural living environment, and increase the incomes of rural villages. The interviews during home garden visits, focus group interview, and document content analyses were synthesized to obtain a more comprehensive understanding of adoption of improved citrus cultivation in Jeju. In addition to the information on Jeju, the rice production statistics and history of the national rice self-sufficiency drive in the 1970s were analyzed for comparison. The goal of the comparison was to examine differing experiences of the adoption of improved varieties (citrus, rice) and the roles of the South Korean state in different regions and for different crops. For a finer-scale examination, the history of Jangseong, a rural county in mainland Korea whose main crop has been lowland rice, was also analyzed.

Chapter 4: Data collection and analysis (interview, land use and land cover, and overlap analyses)

The plant inventories from the home garden visits were analyzed in terms of plant traits (e.g., uses, plant habit) to 1) identify the relative abundances and uses of domesticated and wild plants in home gardens and 2) identify ethnobotanical plants found and not found in the sampled home gardens. The list of ethnobotanical plants, which are defined as native (wild) plants traditionally used according to local knowledge, was derived from the work of Kim, Jeong, and Kang (2015), which was conducted across the province. The first comparative analysis examined the unique contributions of wild plants to the household's livelihood. The second helped clarify which traits of useful wild plants make them more likely to be cultivated in home gardens as opposed to harvested from the wild.

For a more in-depth examination of wild plant use and management, the author conducted in-depth interviews (n = 6) with home garden tenders in three focus villages selected from the 12 villages who had expert knowledge of wild plants. The interviewees were asked more targeted questions regarding the use and management of wild plants and the source sites of the wild plants in their home gardens. If the interviewees perceived a change in the availability of the plants in the wild, they suggested the reason and indicated when the change was most noticeable, as well as their response to the change. Further anecdotes on wild plant use in Jeju were acquired from published online sources (blog posts, television documentaries) to complement the information from the in-depth interviews.

The chapter also examined geographic (village-level) variations and historical changes in land use and land cover in Jeju as a factor that affected home garden plant diversity. The study examined the land use and land cover statistics of the 12 villages and changes in land use and land cover on maps during 1972–2016. These data and the information obtained in the interviews were analyzed to examine potential effects on the availability and accessibility of nearby plant habitats and local plant users' responses to changes in plant habitats. The statistical relationship between the land use and land cover composition of the village and the diversity of wild plants in the village's home gardens was examined. A positive correlation may indicate that plant habitats in the surrounding wild land cover can serve as a source of wild plants for home gardens. Conversely, the scarcity of such habitats in the surrounding area may cause local plant users to change their management of useful wild plants to secure their plant supply (e.g., by the transfer of plants to home gardens).

To analyze the changes, government-produced maps of land use and land cover data (1:25,000 scale) were used as primary data sources between 1972 and 2016. Satellite images and aerial photographs taken in the 1970s were not used owing to issues with their availability and clarity. However, the maps provided detailed land use and land cover information from aerial photographs and ground surveys, providing spatial information with better resolution and accuracy. During 1972–1997, agricultural commercialization and thus farmland expansion occurred. The period 1997–2016 saw further agricultural and other land development amid livelihood diversification.

1.7 General introductions to chapters 2–4

Chapter 2 serves two purposes: 1) it is a stepping stone to the other empirical chapters, providing basic (aggregate) information on home gardens, garden tenders, and cultivated plants in Jeju, and 2) it provides an independent analysis that employs statistical methods, including regression and ordination, to identify household, community, and higher-level geographic factors that affect home garden plant diversity and composition. Livelihood diversification (approximately after the 1980s), which transformed the available livelihood options and demography of rural Jeju but did so unevenly, informs the selection of geographic divisions and household-level independent variables. In this chapter, the current state of *in situ* agrobiodiversity that is managed in home gardens in Jeju is examined and the question of how the agrobiodiversity is related to the contemporary farm and non-farm livelihoods of households is addressed.

Chapter 3 provides a historical context for the subsistence production in contemporary home gardens presented in Chapter 2. Agricultural commercialization and cash crop adoption (beginning in 1960) resulted in a pronounced loss in the agrobiodiversity of traditional staple crops. Questions such as why and how farmers in Jeju willingly adopted cash crops of little subsistence value (e.g., citrus) when they still needed subsistence production to survive are addressed in Chapter 3. It was found that farmers could use home gardens for both subsistence production of supplementary food and citrus production to exploit the opportunity for a high return. The adoption story of Jeju citrus, which was economically successful and well-received by farmers, is compared with the much less successful adoption of improved rice varieties in rice-producing regions during part of this era (the 1970s). In addition to considering local and crop-specific factors, the chapter analyzes the diverging outcomes in relation to differing attitudes of the South Korean state toward different crops and subnational regions. The chapter draws upon the political ecology literature on the complexity of state and local actors' understanding of marginal land (Scott 1998; Ariza-Montobbio et al. 2010; Baka 2013) and cautions against prescriptive use of marginal land for cash crop development.

Chapter 4 focuses on the role of the home garden as a node within the network of sites within which locally used wild plants are managed. Wild plants in home gardens are examined, and the roles of wild plants in local livelihoods and of home gardens in wild plant management are investigated. A geographical-ethnobotanical hypothesis is tested by establishing a positive statistical connection between wild plants in home gardens and the surrounding wild habitats as source sites of these plants. This chapter also investigates how changes in the surrounding land cover and land use trigger changes in plant management (e.g., transfer to home gardens). The results confirm the role of the home garden as a site where useful plant taxa of value to garden tenders is conserved.

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Chapter 2

Cultivated plant diversity in home gardens of Jeju, South Korea, and its determinants amid pronounced livelihood diversification

2.1 Introduction

A home garden is an area adjacent to a house where household members manage crops and other plants, and often raise animals, of value to the household (Kimber 2004; Kumar and Nair 2004). It typically has higher plant diversity than most other cultivated lands (e.g., crop fields; Galluzzi et al. 2010; Kumar and Nair 2004; Trinh et al. 2003). Home gardens also often function as experimental sites for new germplasm and repositories for underused germplasm from agricultural lands (Ban and Coomes 2004; Das and Das 2015; Barbhuiya et al. 2016). The agrobiodiversity of home gardens, in turn, provides households with nutritious, diverse food and other livelihood necessities (Galhena et al. 2013; Sander and Vandebroek 2016) and could help retain social networks and cultural identities at the community and higher geographical levels (Kortright and Wakefield 2011; Perreault 2005; WinklerPrins 2002). Despite the benefits, the maintenance of home garden agrobiodiversity may be contingent on many factors. The necessities and resources to cultivate plants in home gardens vary by the community and household and wider socioeconomic and biophysical contexts that affect the plant cultivation practice (Kehlenbeck et al. 2007). The decision to cultivate plants in home gardens is also cultural, rather than a strictly economic choice (Perreault 2005; Pritchard et al. 2019), especially in industrialized countries where the absolute necessity for home garden products have dwindled (Pearsall et al. 2017; Taylor et al. 2017).

Livelihood diversification, as part of deagrarianization, has profoundly changed the context of agrobiodiversity management practices in rural home gardens. Rather than relying predominantly on agriculture, rural residents are seeking off- or nonfarm employment (Bryceson 2002; Ellis 2000) at farther distances than before (Rigg 2006; Rigg et al. 2012) while increasingly relying on remittances and other nonfarm incomes (Martin and Lorenzen 2016; Peluso and Purwanto 2018; Yarnall and Price 2010). Such livelihood changes often incur land changes ranging from forest resurgence to increased subsistence-to-commercial cropping (Hecht 2014; Lambin and Meyfroidt 2011; Peluso and Purwanto 2018). Additionally, rural communities are less uniformly agrarian in their demographies than before, especially in places where in-migration co-occurs with the exodus of the native population to cities (e.g., Jeju, South Korea; Bu 2015).

The land, livelihoods, and demographic changes affect the agrobiodiversity of home gardens. Households diversified in their income may reduce investment in agrobiodiversity-based diversification strategies (Baumgärtner and Quaas 2007). Livelihood diversification and related migrations have been linked to complex changes to smallholder agrobiodiversity management and the social and environmental conditions of rural and peri-urban locales that often favor partial conservation of local agrobiodiversity in fields and home gardens (Zimmerer, Carney, and Vanek 2015; Zimmerer and Vanek 2016). On the other hand, home garden spaces have been encroached on by new housing and business developments in communities experiencing in-migration (Behera et al. 2016; Hyun 2011). In response to changed land use and livelihoods, garden tenders adopt modified management strategies ranging from the use of home gardens for commercial production to increasing plant diversity in home gardens to compensate for reduced agrobiodiversity in crop fields (Friis et al. 2016; Serrano-Ysunza et al. 2017; Steward 2013; Vogl-Lukasser and Vogl 2018). In addition, a diminished agrarian identity in rural communities can negatively impact seed-saving practices, reducing locally maintained agrobiodiversity in general and in home gardens (Korea Women Peasant Association 2013).

This study reports on the first recorded large-scale survey of standing plants in home gardens of South Korea by investigating what roles the home garden-cultivated plants play in contemporary Jeju households amid tourism-related livelihood diversification and demographic changes. To achieve this end, this study examines the diversity, abundance, and composition of cultivated plants in home gardens; garden tenders' management of plants in home gardens; and the impacts of household, community, and higher-level geographical factors on the diversity, abundance, and composition. The 12 study villages varied in demographic, livelihood, and biophysical characteristics, including elevation, level of development, and selection of commercial field crops. The variations and household-level factors (e.g., presence of nonfarm income) were hypothesized to affect home garden plant diversity, abundance and composition by affecting the needs and resources necessary for home garden plant cultivation and the culture and lifestyle of the garden tenders.

2.2 Study area and methods

2.2.1 Characteristics of the study area and the status of livelihood diversification

The home gardens studied are in Jeju Province (Figure 2.1), one of seven administrative provinces of South Korea. This province consists of an oval island of 1,833 km² and smaller islands and has a warm temperate to subtropical climate (monthly average temperature is 5.7°C–27.1°C, and annual precipitation is 1,500–1,800 mm). The elevation ranges from the coast to 1,950 m above sea level (at the peak of Mount Halla), creating an altitudinal gradient of plant communities from alpine vegetation to evergreen broadleaf forests. Settlements are concentrated along the coast, with a few higher-altitude villages at 100–400 m above sea level. The land cover mainly consists of forest and other natural areas (47%), agriculture (29%), and pasture (9%), with an increasing area of built-up land. The ethnic composition was predominantly Korean (97.4%) in 2015.

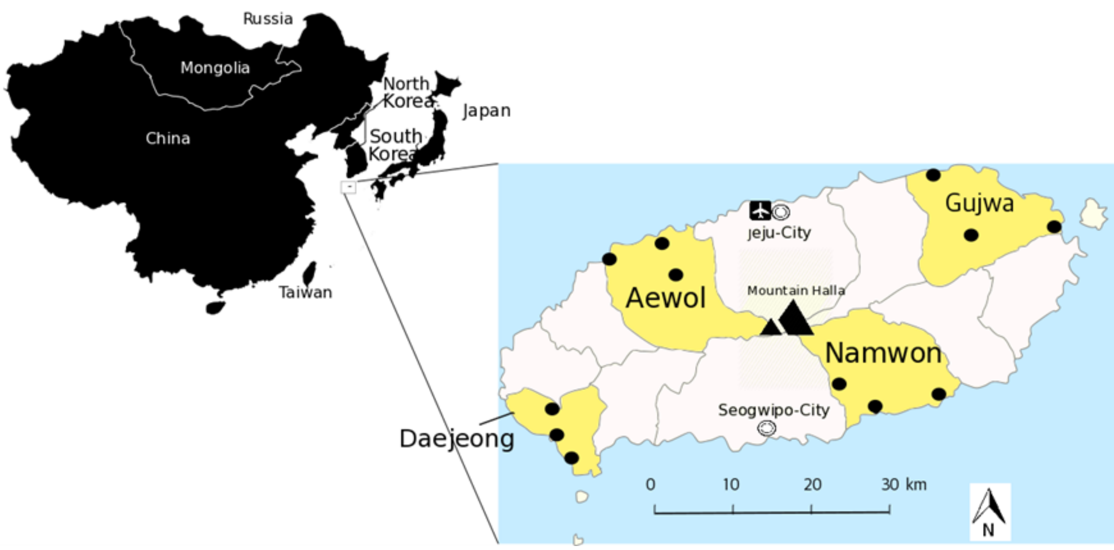
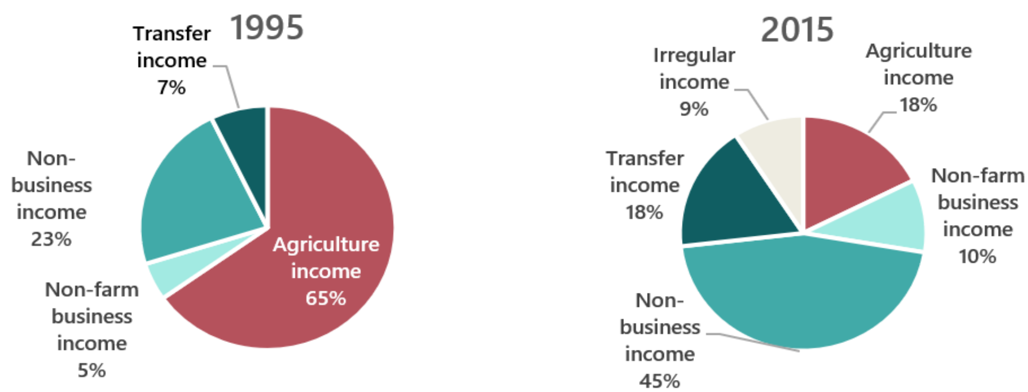


Image sources: (left) Zuanzuanfuwa (2009), (right) modified from Asfreeas (2011)

Figure 2.1: Map of Jeju Province and locations of the 12 study villages (filled dots on the map) within four study subregions (shaded yellow on map)

The province's main income source is agriculture and tourism-related industries. The agricultural industry has been highly commercialized since the 1960s, and most farm households produce tangerines ("citrus" hereinafter) and vegetables for market in mainland South Korea. The transition has successfully increased the region's income. Agriculture in Jeju has remained predominantly smallholder based, with 85% of farm households having under 2 ha of landholdings (Statistics Korea 2015a), similar to other rural regions in East Asia (Lowder et al. 2016). Tourism has long been the second most important industry in the region in terms of gross value added (Bank of Korea 2018). The number of annual visitors to the island has recorded approximately 15 million since 2016, making it one of the most popular regions for tourists in the country. Other livelihoods, such as fishing and animal raising, have maintained a steady presence but have transformed from supplementary subsistence livelihoods to specialized production for sale.

Rural livelihoods in Jeju have been profoundly changing toward diversification. The proportion of farm income in the farm household economy has greatly decreased (Figure 2.2), and 39.8% of Jeju farm households were farming full time in 2015. In the same year, 29% of households in rural Jeju were farm households, decreasing from 84% in 1960 (Statistics Korea 2015a, 2015b). The decreased importance of agriculture reflects increased uncertainties regarding the continued profitability of citrus amid increasing levels of international and domestic competition.



Data source: Statistics Korea (1995, 2015c)

Figure 2.2: Changes in proportions of income categories in Jeju farm households (1995–2015)

Additionally, the impetus of deagrarianization is that tourist incomes have become crucial for Jeju's regional economy since the 1980s. Primarily in pursuit of economic opportunities in tourism and the benefits of Jeju's natural amenities, the numbers of domestic in-migrants increased, especially since 2010. They could be grouped as return-to-farming (or return-to-countryside) population, entrepreneurs, artists (Choe and Kim 2015). Some in-migrants followed their jobs and high-end education, the site of which was intentionally relocated to Jeju following government policies to foster decentralization and easing of population pressure in greater Seoul area (Choe and Kim 2015): Several important mainland corporations like IT companies moved to Jeju following the newly created tax benefits for corporations moving from the greater Seoul area to Jeju. High-end international schools were established in Jeju to attract households that sought to educate their children in the schools. The formerly homogeneous rural communities of Jeju became demographically patchworked in terms of native status, having lost their native members because of the exodus of young adults to cities and received the in-migrant households. Rarely engaged in farming and generally younger, the newcomers do not tend to socially integrate with the natives (Bu 2015).

2.2.2 Study approach: Geographic crossed design (four subregions × three villages)

To study the impacts of demographic, livelihood, and biophysical variations on plant diversity and composition in home gardens in Jeju, this study created a cross-sectional and crossed (four subregions × three villages) study design. The study investigated the cultivated plants of sample home gardens (n = 131) in 12 villages and divided them into four selected subregions of Jeju (Figure 2.1, Table 2.1). The four subregions represent high-level biophysical variations (in climate and soils) that have shaped the livelihood choices of their households. For one, having less volcanic ash soil content than the eastern part of the island, the western part is generally distinguished by having higher soil fertility (e.g., Gujwa subregion). The East-West division thus contributed to different agricultural productivity levels in these regions which, in turn, developed different land management systems (Ko 2018). Northern subregions typically had approximately 0.6°C higher winter temperature than the southern subregions.

As a result, intensive citrus farms were established mainly in southern subregions, especially the southeastern regions where the productivity level of traditional crops was not high due to soil constraints of eastern regions. Upon the underlying biophysical conditions, subregions have developed different traditional livelihood systems and contemporary crop specializations. As the livelihood diversified, some subregions also retained agrarian traits better than other subregions. Table 2.1 presents the livelihood and demographic statistics of the four subregions, especially the statistics that pertain to livelihood diversification.

For each of the four subregions, three villages were selected: two coastal villages and one mid-hill village. In Jeju, coastal villages generally had better access to infrastructure (e.g., large supermarkets) and were more developed than mid-hill villages. However, the level of development and population density varied significantly between coastal villages. Therefore, in addition to one mid-hill village, two villages of varying levels of development were selected to encompass variations between coastal villages. Combining the variations, this study classified the villages into three categories:—A (coastal and more developed), B (coastal and more rural), and C (mid-hill)—for analytic convenience. The summed traits of each village type are outlined in Table 2.2. Table 2.5 shows the number of samples selected from each subregion and village.

Table 2.1: Characteristics of studied subregions in Jeju in 2015

		Jeju-si (North)		**Seogwipo-si (South)**	
		Aewol	**Gujwa**	**Daejeong**	**Namwon**
Main crop specializations		Cabbages, broccolis	Carrot, radish, soy	Garlic, onion	Citrus
Area and locational characteristics (area in ha)	Administrative area	20,216	18,593	7,863	18,871
	Citrus cultivation area	874	42	409	2,125
	All cultivation area	3,430	4,385	3,385	3,332
	Distance to urban center (km)	15.4–23.4	22.6–38.8	27.3–28.4	10.2–18.7
Demography and livelihoods	Total population	31,560	15,175	19,560	19,095
	Total households	13,018	6,889	8,211	7,812
	Farm households (%)	2,479 (19%)	1,650 (24%)	1,867 (22.7%)	2,710 (34.7%)
	Area of farmland per	1.38	2.65	1.81	1.23
	% full-time farm	54	24	51	50
	Mean no. of household members	2.42	2.20	2.38	2.44
	% population over 60	14.4	47.7	28.6	30.4
Traditional agrobiodiversity and ethnobotany	Number of landrace seed holders*	9	20	11	0
	Number of ethnobotanical knowledge holders**	8	11	19	8

Data sources: Statistics Korea 2015b, 2015d
* Korea Women Peasant Association 2013; ** Korea National Arboretum 2017

Table 2.2: Classifications of Jeju villages by elevation and development

	Coastal villages		**Mid-hill village**
	A (Developed coastal)	B (Rural coastal)	C (Mid-hill)
Population density	High	Lower	Lowest
Average homestead area	Smallest	Larger	Largest
Landraces recorded*	Less abundant		More abundant
Infrastructures (e.g., administrative, commercial)	More developed	Minimal	Minimal
Presence of fresh food market in village	Yes	No	No

* Korea Women Peasant Association 2013

2.2.3 Data collection

Within each of the 12 villages, 10–14 households were randomly selected for home garden visits between June and August 2015. The author performed two tasks at each of the households who gave informed consent during the visit. The first task was to identify and count all plant taxa (stem counts) being cultivated in the home garden. The second task was to ask the garden tender(s) about the household's demography and livelihoods and the management of the home garden. All interviews were conducted in Korean. After the visit, the author recorded physical information on the home and the home garden: the home garden area, the homestead area, and the household elevation, by using an online map service with area calculation and elevation finder features. The information gathered is presented in Table 2.3.

Table 2.3: Information sought on household, garden tender(s), and home garden

	Category		**Information sought**
Home garden visits (n = 131)	Cultivated plant inventory		Taxa name and stem counts of all plants in the garden
	Garden tender interview	Demography	**(Household-level)** family native status, age of the main house building, number of household members, presence of extended family in Jeju **(Individual-level)** age and gender of main garden tender
		Livelihoods	**(Farm households)** total farmland area, list of field crops under cultivation, presence and type of nonfarm income **(Nonfarm households)** current occupation, farming experience
		Home garden management	Source of planting materials of home garden plants, motivation for home garden plant cultivation
Off-site measurement			Homestead area*, home garden area*, household elevation**

Data sources: * Daum online map and aerial photograph service (http://local.daum.net)
** Elevation finder – FreeMapTools (http:// https://www.freemaptools.com/elevation-finder.htm)

The plants were identified by the garden tenders by their local names, an efficient method that has been used in the literature (e.g., Coomes and Ban 2004; Perrault-Archambault and Coomes 2008). For identification accuracy, the plant list was later matched with plant lists of prior home garden studies in the area (Hyun 2011; Korea Women Peasant Association 2013), a list of ethnobotanical plants (native plants traditionally used in the locale) (Kim et al. 2015), and an illustrated encyclopedia of Korean crops and crop landraces (Ahn 2009). Plants were primarily identified and analyzed at the species level, and high infraspecific variations such as those in *Brassica oleracea* were recognized as different taxa.

2.2.4 Data analysis: Methods and hypotheses

First, this study characterizes Jeju home gardens and home garden-tending households; next, it analyzes plant composition and diversity in Jeju home gardens at the aggregate level, including botanical families and use groups of the plants. Subsequently, variations in the diversity and composition between geographic divisions are examined. One-way analysis of variance (ANOVA) and the Tukey-Kramer HSD tests were performed to examine whether the divisions differ significantly in the diversity and abundance of cultivated plants. JMP Pro 14 was used to perform ANOVA and the Tukey-Kramer HSD tests. Plant compositions were analyzed in an ordination analysis (nonmetric multidimensional scaling [NMDS]) by using the Bray-Curtis distance matrix of the plant abundance data. The software package PRIMER-e was used for the analysis. The geographical divisions were individual villages, subregions, north-south, east-west, and the A–C village types described in Section 2.2.3. For ANOVA, taxa richness values were subdivided—all plants, the plant's life form, native status, and use group—to examine if any significant result emerges by category.

A general hypothesis of this study is that the biophysically relevant divisions (north-south and east-west) are expected to have less importance today in determining agrobiodiversity in home gardens than human factors do (e.g., level of development of the village) because technological advances could surmount biophysical constraints (Kehlenbeck et al. 2007). However, some biophysical factors such as elevation may influence home garden agrobiodiversity because of mediating human factors. For villages not well developed or distant from developed areas, residents have difficulty acquiring food and livelihood necessities from stores. Additionally, nonfarm income opportunities are concentrated along the coast and especially in more developed areas. The opportunities may provide the residents with the purchasing power to buy substitutes for home garden products and reduce their time available for home garden tending. Thus, home garden tenders geographically isolated are expected to rely more on home garden production, resulting in higher taxa richness and abundance of home garden plants.

To determine household-level factors that may affect the plant diversity and abundance of home gardens, stepwise multiple regression analyses were performed, using JMP Pro 14 as the software. Two regression models were established: one for all households and one for farm households. The two-model approach was necessary because the farm households were asked additional questions to specify their farm characteristics (e.g., list of field crops), adding a set of independent variables. The dependent variables were taxa richness (basic diversity measure) and abundance of all plant species by stem counts (measure of home garden activity level and contribution to the household). The forward selection method was used and the independent variables were selected to minimize Akaike Information Criterion (AICc). Categorical interview responses from home garden tenders (e.g., gender of home garden tenders) were transformed into categorical independent variables to be included in the models.

From the sample of n = 131 home gardens, statistical outlier households (home gardens that harbored over n = 750 plant individuals) were excluded (n = 8) from the ANOVA, ordination, and regression analyses but included in the plant lists in Table 2.4 and the appendix. In addition to harboring much higher number of plant individuals than average sampled garden (average 213.2 individuals per garden), outlier gardens were excluded because they were characterized as having significantly different levels of taxa richness range (extremely low or extremely high) and because they served different purposes than the other sampled home gardens that primarily were a complement to livelihoods through the production of food and other useful plants. By contrast, a few of these outliers (n = 2) were being utilized as an extension of commercial soy fields that had only one species of crops. The others were hobby gardens (n = 6) whose garden tenders recreationally collected plants in extraordinary diversity (average = 29.83 taxa per garden whereas the mean taxa richness elsewhere was 9.95), unlike other gardens in Jeju whose cultivated plants were planted with an intention to serve as livelihood necessities.

The hypotheses involved in the regression analyses are as follows. In each parenthesis is a predictor variable hypothesized to affect the dependent variables. The household size affects the food and livelihood demands of the household, which determine the abundance and diversity of plants cultivated (number of household members). Similarly, the presence of family nearby (presence of extended family in Jeju) may necessitate a higher abundance and diversity of home garden plants to accommodate the needs of the family. Plant cultivation in home gardens may also be discouraged if the family network serves as a social safety net and reduces the need for subsistence production. A subset of Jeju demographics may have a higher cultural and lifestyle affinity for managing a higher diversity and abundance of plants in their home gardens (e.g., female, elderly, Jeju-native, farmers or individuals with farming experience). Although farming experience can facilitate plant cultivation in home gardens, current engagement in farming may take time and other resources from home garden tending, negatively affecting plant cultivation in home gardens (total farmland area). In Jeju, citrus is one of the high-return and less labordemanding crops; therefore, citrus-producing households may have less need for home garden plant products but may have more time to spend in home garden plant cultivation (citrus cultivation). Other livelihood commitments may have similar distracting effects on plant diversity in home gardens (presence of nonfarm livelihoods, number of field crops). Having a high number of commercial field crops may also positively affect home garden plant diversity because the farmer and garden tender may have a personal tendency to favor an agrobiodiversity-based diversification strategy.

2.3 Results

2.3.1 Characteristics of the sampled households and the rural population in Jeju: Differences between households with and without home gardens

Demographically, Jeju natives comprised 87.5% of the respondents. The respondents' average number of years of residence was 47.6, and more than 70% had lived in the house for 25 or more years. The number of family members varied from 1 to 10, averaging 2.67 persons per household. Of the 129 respondents, the average age of the garden tender was 68 (ranging from 20 to 94). Seventy-five (58.1%) gardens were managed by a sole female garden tender, 33 (25.6%) by a sole male garden tender, and 21 (16.3%) by both female and male garden tenders. In terms of livelihoods, 89 (70.1%) of the sampled households were engaged in farming, and two-thirds of the currently farming households were farming full time.

Compared with the population in rural Jeju (Statistics Korea 2015c), the following characteristics were observed in the sample. The female ratio in the sample was higher than the 5:5 ratio in the population, indicating that women are more highly involved than men in home garden plant cultivation. Additionally, the sample had a larger number of long-time (25+ years) residents (70.2%) than the general rural population (35.5%) did. Similarly, over 87% of the sample households (n = 111) had farming experience and over 70% (n = 89) were engaged in farming. In the population, the farming households were a minority (30%). Such differences indicate that the female, long-time residents and farming populations in rural Jeju are more likely to cultivate home garden plants than others.

2.3.2 Characteristics and management of home gardens in Jeju

The total studied area of home gardens from the n = 131 samples was 4.22 ha. The average home garden area was 321 m^2, ranging from 27 to 1,897 m^2. More than 80% of the studied gardens were less than 500 m^2. The small area of Jeju home gardens is partly because of the traditionally narrow interhousehold spaces in Jeju villages. Homesteads in Jeju averaged 632.8 m^2 (0.06 ha) and ranged from 146 to 2,477 m^2. The elevation of households averaged 62.78 m and ranged from 1.32 (coastal) to 314.28 m (mid-hill) above sea level. Each garden had an average of 213.2 plant individuals per garden (ranging from 2 to 643). Figure 2.3 presents the types of Jeju home gardens for reference.

(a)

(b)

(c)

(d)

Figure 2.3: Photos of types of home gardens in the study area:
(a) subsistence vegetable garden, (b) commercial soy garden, (c) subsistence vegetable garden layered under commercial citrus trees, (d) taro plants next to a commercial citrus stand

For farm households, the average farmland area under cultivation was approximately 1.6 ha (16,113 m^2), with a range of 826 to 49,587 m^2. On average, the number of field crop taxa was 2.02 per household. Home gardens occupied on average approximately 6% of the landholdings, ranging from 0.33% to 55.2%. While occupying a minimal area, the average home garden contributed to 81% of all cultivated taxa in all the household's cultivated fields, ranging from 16.7% to 96.4% of all cultivated taxa. Factors that influenced the areal proportion in Jeju were the age of the garden tender (positive correlation) and the household's number of sources of income (positive correlation), which together explained 17.7% of the variation as a model ($F = 6.7154$, adjusted $R^2 = 0.1221$, $t = 0.0026$). The result could indicate that the importance of home gardens increases (1) as farmers' age and relinquish some or all of the farmland that is not a home garden due to declining health or insufficient household labor, and (2) because the household has diversified sources of income that make it difficult to maintain large areas of farmlands outside home gardens.

The motivations for home garden tending were mainly food self-provision and the healthfulness of food, according to interview responses performed during home garden visits. By producing their food, the garden tenders sought to lower food costs, avoid trips to food markets, and avoid agrochemicals in purchased foods. Aesthetic pleasure from the garden plants, recreation, and physical health from garden work were also cited. Mid-hill village garden tenders especially cited the need for home garden foods because of the absence of stores in the village area that sold fresh food. Additionally, food self-provision had identity aspects. Many respondents cited reasons for home garden production that were similar to the following: "I produce my own food because I am a farmer," and "This (subsistence food production) is how rural people live."

The planting materials for home gardens were mainly bought from professional sellers at seed stores, agrochemical stores, and periodic markets or were sometimes gifted to customers from local businesses. The distributers of planting materials sourced them from professional breeders based mainly in mainland South Korea. Experienced garden tenders also self-sourced seeds from the prior year's harvests, especially legumes and seed plants. Some of the seeds were inherited from the garden tender's parents or parents-in-law and many woody plants in the gardens were inherited along with the house. However, some garden tenders reported having stopped saving seeds. Purchased or gifted planting materials were readily available at affordable costs and reduced the motivation for seed-saving practices. Garden tenders knowledgeable of wild plants also reported having transferred plants or taken cuttings from the nearby wild and semi-wild areas to populate their gardens. Some garden tenders also received materials from friends, neighbors, and family members as gifts.

2.3.3 Diversity and composition of cultivated plants in Jeju home gardens

The total number of unique plant taxa in all the home gardens studied (n = 131) was 164, corresponding to 153 unique species and five additional species whose varieties were recognized as 11 taxa (e.g., broccoli, kale, and cabbage in the species *Brassica oleracea*). Excluding outliers (n = 8 gardens), the taxa number was 145. The average number of plant taxa per garden was 9.95, with a median value of 9 per garden, ranging from 1 to 67 (including outliers), or 27 (excluding outliers). The 164 taxa corresponded to 125 genera and 63 families. One hundred and nine (66.5%) of the taxa were domesticated, 52 (31.7%) were native (wild), and 3 (1.8%) were introduced. By life form, 64 were trees, shrubs, and woody vines, and the other 100 taxa were herbaceous: 36 annuals, 7 biennials, and 57 perennials.

The most represented botanical families were Asteraceae (15 taxa; 9.1%); Rosaceae (14; 8.5%); Fabaceae (11; 6.7%); and Araliaceae, Lamiaceae, Liliaceae, and Rutaceae (8 each; 4.9% each). When ranked by the number of total plant individuals, the families most represented were Fabaceae (16.6%, including edible legumes); Liliaceae (14.2%, *Allium* taxa), Solanaceae (14.1%, chilis and eggplants), Lamiaceae (9.6%, perilla and other spicy vegetables and herbs); and Cucurbitaceae (7.8%, squashes and cucumbers).

High idiosyncrasy between home gardens in terms of taxa composition was observed. Only one taxon (*Capsicum annuum*) occurred in more than three-quarters of the sample home gardens (104 of 131 gardens, 79.4%), and two additional taxa (*Lactuca sativa*, *Perilla frutescens*) were observed in more than half of the gardens. Fifty-six of 164 (34%) taxa occurred in only one of the 131 gardens, and an additional 27 taxa (16.5%) and 14 taxa (8.5%) occurred in two and three gardens, respectively. Overall, approximately 60% of the taxa occurred in less than four of the 131 gardens. The 25 taxa with the highest occurrences are listed in Table 2.4.

Among the plants, the use group that contained the most taxa was food, comprising 113 of 164 taxa (68.9%). This group was followed by ornamentals (26 taxa, 15.9%), medicinals (22 taxa, 13.4%), and others, including craft plants (3 taxa, 1.8%). Most taxa found in this study's home gardens had more than one use, averaging 1.84 uses per taxa. The most frequent use combination was food–medicine, comprising 87 of the 113 food taxa (77%). Some taxa provided multiple categories of foods, such as *Glycine max* (leafy vegetable and seed) or *Perilla frutescens* var. *japonica* (oil, seed, and leafy vegetable).

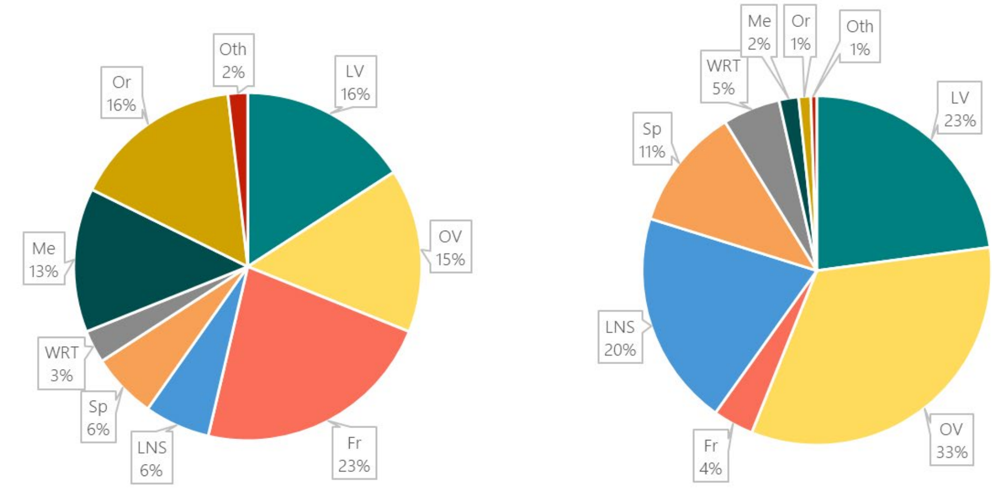
Among the food plant taxa, the dominant category was vegetables (51 taxa, 31% of all 164 taxa; 26 leafy vegetables and 25 other vegetables), followed by fruits (37 taxa, 22.6%); legumes, nuts, and seeds (10 taxa, 6.1%); spices (10 taxa, 6.1%); and white roots and tubers (5 taxa, 3%; Figure 2.4, left). In relative abundance (% number of plant individuals), the dominance of food plants and vegetables were 96.5% and 56%, respectively (Figure 2.4, right). Among other food groups, legumes, nuts, and seeds (20%) and spices (11.4%) had a higher relative abundance. The proportion of fruit individuals was not substantial (3.8%) because most fruit trees were cultivated in small quantities.

Table 2.4: List of the 25 most common cultivated plant taxa in Jeju home gardens

Scientific name	English common name	Use	Occurrences			
			Number of gardens	Number of villages	% of all gardens	Total abundance
Capsicum annuum	Chili pepper	Sp, OV	*104*	12	79.4	3517
Perilla frutescens	Common perilla	LV, OF, LNS	68	12	51.9	3189
Lactuca sativa	Korean lettuce	LV	*68*	12	51.9	1780
Diospyros kaki	Persimmon	Oth, Fr	*65*	11	49.6	118
Cucurbita moschata	Asian pumpkin	OV, LV	*63*	11	48.1	1043
Cucumis sativus	Cucumber	OV	*61*	12	46.6	993
Solanum melongena	Eggplant	OV	*52*	11	39.7	477
Allium tuberosum	Chive	OV, Sp	*50*	10	38.2	1840
Allium fistulosum	Green onion	OV, Sp	*42*	12	32.1	809
Glycine max	Soy	LNS, LV	*40*	11	30.5	2652
Brassica rapa	Asian cabbage	LV	*36*	12	27.5	1494
Lycopersicon esculentum	Tomato	OV	*34*	10	26.0	417
Zingiber mioga	Myoga ginger	OV, LV, Sp	*30*	11	22.9	1208
Citrus unshiu	Citrus unshiu	Fr, Med	*29*	9	22.1	77
Camellia japonica	Camellia	Or, Med. Oth	*24*	10	18.3	100
Ipomoea batatas	Sweet Potato	WRT	*23*	11	17.6	1268
Phaseolus vulgaris	Common bean	LNS, LV	*20*	8	15.3	2289
Raphanus sativus	Asian radish	WRT, LV	*19*	10	14.5	569
Zea mays	Corn	OV	*19*	7	14.5	1019
Zanthoxylum piperitum	Korean pepper	Sp, Oth	*17*	11	13.0	140
Colocasia esculenta	Taro	WRT, OV	*17*	8	13.0	176
Peucedanum japonicum	Coastal hogfennel	LV	*16*	7	12.2	186

Ficus carica	Fig	Fr	*16*	7	12.2	25
Citrullus vulgaris	Watermelon	Fr	*15*	9	11.5	230
Allium sativum	Garlic	OV	*14*	6	10.7	1711

Sp: Spices, OV: Other vegetables, LV: Leafy vegetables, OF: Oils and fats, LNS: Legumes, nuts, and seeds, Fr: Fruits, WRT: White roots and tubers, Med: Medicinal, Or: Ornamental, Oth: Other uses



Abbreviations: LV: leafy vegetables, OV: other vegetables, Fr: fruits, LNS: legumes, nuts, and seeds, Sp: spices, WRT: white roots and tubers, Me: medicinal, Or: ornamental, Oth: other uses

Figure 2.4: Proportions of use groups according to the number of taxa (left) and individuals (right) of cultivated plants in Jeju home gardens

2.3.4 Geographical variation of diversity, abundance, and composition of cultivated plants in Jeju home gardens

Table 2.5 presents the diversity results of home gardens per village and subregion. The village with the highest mean taxa richness was Yusuam of the Aewol subregion (northwest, mid-hill), with 14.4 taxa per home garden. Hamo of the Daejeong subregion (southwest, Type A coastal) scored the lowest with 6.2 taxa in the average number of taxa per garden (alpha diversity). These two villages also ranked first (58 taxa) and last (34 taxa) in the total number of taxa found in all home gardens in the village (gamma diversity). The alpha and gamma diversity values were calculated from home garden plant occurrence data collected by n = 131 home garden visits. By subregion, Aewol had the highest total and mean number of plant taxa cultivated in home gardens, followed by Gujwa, Namwon, and Daejeong.

Despite the differences in the raw values, a one-way ANOVA analysis on taxa richness found no significant between-village variations, and the Tukey-Kramer HSD test demonstrated that the means were not significantly different. The total plant abundance, however, varied significantly among villages (adjusted $R^2 = 0.126119$, $F = 2.6006$, $p = 0.0056$). The Tukey HSD test on the abundances separated Yusuam (346 plant individuals per garden) and Hamo (115 plant individuals per garden).

Next, this study examined plant diversity and abundance in home gardens by geographical divisions higher than villages (north-south, east-west, and village types). Some tendencies emerged by village type (Table 2.6). Within each subregion, each of the four mid-hill villages (village type C) had the highest alpha and gamma diversity values, followed by village type B (coastal, more rural villages) and village type A (coastal, more developed villages). An exception to this trend was the Aewol subregion, where Shineom (type B) had slightly lower diversity than Gwakji (type A) did.

Table 2.5: Cultivated plant diversity of Jeju home gardens at the village level (village type: A: coastal, more developed; B: more rural; coastal, C: mid-hill)

Subregion	Village type	Village name	Sample size (n)	Mean number of taxa (α)	Total number of taxa (γ)	
Aewol	A	Gwakji	10	10.3	49	91
	B	Shineom	10	10	44	
	C	Yusuam	8	14.4	58	
Gujwa	A	Gimnyeong	9	9.2	39	83
	B	Jongdal	10	9.7	48	
	C	Songadang	10	11.9	42	
Daejeong	A	Hamo	11	6.2	34	75
	B	Ilgwa	10	9.4	50	
	C	Mureung	9	9.9	38	
Namwon	A	Wimi	14	7.3	37	75
	B	Taeheung	12	11.4	50	
	C	Harye	10	11.7	53	

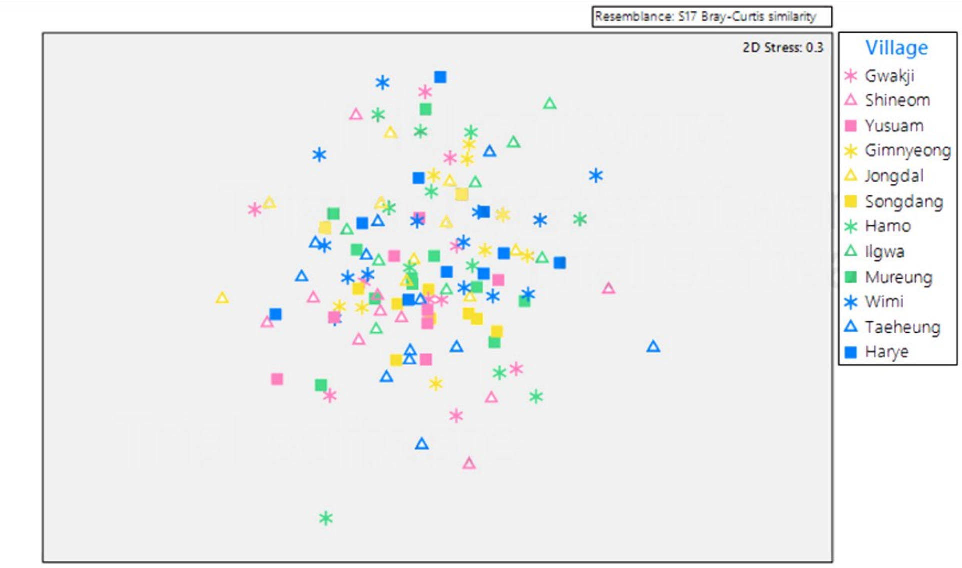
ANOVA analyses results in Table 2.6 demonstrate that village type was the most influential geographical division among all geographical divisions on taxa richness values. Mid-hill villages (C) tended to have higher taxa richness than developed coastal villages (A) in all taxa, in annuals and biennials, in domesticated and native taxa, and in all use categories except for ornamentals. B villages, the rural coastal villages, contained a significantly larger number of plant individuals (total plant abundance) than A villages did, although the taxa richness was not significantly higher. Geographical divisions other than village type did not produce significant differences in taxa richness by native status or use group. Annual and biennial taxa were significantly richer in northern home gardens than southern ones.

Table 2.6: One-way ANOVA results on home garden plant geographical divisions

			Subregion	**North(N)-South(S)**	**East(E)-West(W)**	**Village types A-C (Table 2.2)**
Home garden plant taxa richness	All plants	Taxa richness	ns	ns	ns	C > A, B***
		Total plant abundance	ns	ns	ns	B, C > A***
	Life form	Woody plants	AW > GJ, DJ *	ns	ns	ns
		Perennials	ns	ns	ns	ns
		Annuals and biennials	GJ, AW > DJ *	N > S **	ns	C > A *
	Native status	Introduced	ns	ns	ns	ns
		Native	ns	ns	ns	C > A *
		Domesticated	ns	ns	ns	C > A *
	Use group	Edible	ns	ns	ns	C > A **
		Medicinal	ns	ns	ns	C > A *
		Ornamental	ns	ns	ns	ns
		Others	ns	ns	ns	C > A *

Subregion names: (AW: Aewol, GJ: Gujwa, DJ: Daejeong, NW: Namwon)
Significance levels: * <0.05, ** <0.01, *** <0.001, ns: not significant

Plant taxa composition demonstrated little divergence across the geographical divisions (Figure 2.5). The plot shows an NMDS result to gauge the similarities in taxa compositions of home garden plants between villages, subregions (color of symbols), and village types (symbol shapes) and the north (pink, yellow)-south (green, blue) and east (yellow, blue)-west (pink, green) divisions. The data used to calculate the distance is the abundance data of all plant species present in each home garden (n = 123). The individual points (gardens) do not form any clear separation by color (subregions, north-south, or east-west), symbol shapes (village types), or village. The result indicates that the geographical divisions do not significantly impact the taxa composition of the home garden.



* Each symbol represents an individual home garden (n = 123). Symbol shapes represent village types (A: ✳, B: △, C: ■). Colors distinguish subregions (pink: Aewol, yellow: Gujwa, green: Daejeong, blue: Namwon).

Figure 2.5: Nonmetric multidimensional scaling plot based on the Bray-Curtis similarity matrix for all home garden-cultivated plant taxa by abundance

2.3.5 Household-level factors affecting the diversity and abundance of plants cultivated in home gardens

Table 2.7 presents the results of two models of stepwise regression analyses. In model 1 (farmer-only sample), taxa richness was predicted by five independent variables. The higher elevation (1) of the household positively affected home garden plant diversity, consistent with the observation in the prior section that the mid-hill village had the highest richness. Although mid-hill villages' home gardens tended to have larger areas than those in coastal gardens did, the home garden area (2) in the model did not predict taxa richness, indicating that garden area is not the impetus for the positive correlation between elevation and plant diversity. The area of home garden (2), however, was positively correlated to the total plant abundance. Third, the garden tenders with extended family in Jeju (6) had lower taxa richness and total abundances of home garden plants. Fourth, the number of field crop taxa (8) that the household cultivates positively determined the number of plant taxa in the home garden. Last, farmers that had nonfarm income (10) had higher home garden plant taxa richness than those who did not.

Taxa richness in model 2 was also explained by the household elevation (1) and current farming activity (7) of the household. Inactive farmers (e.g., farmers taking a break because of health issues) had a lower diversity of home garden plants than active farmers and nonfarmers (with a job) did. Additionally, the total plant abundance was positively determined by the area of the home garden (2) same as in model 1. Demographical factors also influenced the results. The age of the main garden tender (12) positively determined the total abundance of the home garden plants. The gender of garden tender(s) (13) was also a determinant of the total abundance: home gardens tended by one female garden tender had a smaller total abundance than gardens tended by one male or multiple garden tenders of any gender.

Table 2.7: Results of stepwise regression analyses on home garden plant diversity and abundance

			Farmers (model 1)		**All samples (model 2)**	
			Taxa richness	**Total abundance**	**Taxa richness**	**Total abundance**
Model (Adjusted R^2)			0.16**	0.12*	0.14**	0.20**
Physical factors		(1) Household elevation (m)	0.02*	ns	0.02**	0.44*
		(2) Home garden area (m^2)	ns	0.16**	ns	0.11*
		(3) Age of main house building	ns	ns	ns	ns
Demographic and livelihood factors	House-hold	(4) Number of household members	ns	ns	ns	ns
		(5) Native (1), non-native (0)	ns	ns	ns	ns
		(6) Presence of extended family in Jeju	−2.77** (1-0)	− 47.96* (1-0)	ns	ns
		(7) Farming activity (1: Active farmer, 2: Inactive farmer, 3: Nonfarmer)	Not included in the model		−1.35* (2-1&3)	−33.84* (3-1&2)
	Farm-related	(8) Number of field crop taxa	1.36**	ns	Not included in the model	
		(9) Total farmland area (m^2)	ns	ns		
		(10) Presence of nonfarm income	−1.39* (0-1)	ns		
		(11) Citrus cultivation as field crop	ns	ns		
	Garden tender(s)	(12) Age of the main garden tender	ns	ns	ns	2.04*
		(13) Gender (1: Male, 2: Female, 3: Both)	ns	ns	ns	−37.21 ** (2-3&1)

* denotes significance levels (*: p>0.05, **: p>0.01)

2.4 Discussion

2.4.1 Plant cultivation in Jeju home gardens and links to rural demography and livelihood changes

Jeju home gardens had lower plant diversity at the species (taxa) level compared to most previously studied home gardens. Home gardens located in temperate regions tend to have lower diversity of plants than those located in tropical regions due to the typical lack of structural complexity (Niñez 1987). However, Jeju's results (9.95 taxa per garden and a total of 164 taxa from 131 gardens) were in the lower range even for home gardens that were located in temperate regions. The diversity level was lower than higher-altitude tropical regions that have been studied to have lower plant diversity than lower-altitude tropical gardens (Kehlenbeck et al. 2007). Home food gardens of the Iberian Peninsula, western Nepal, and Chicago ranged from 10 to 30 species (Reyes-Garcia et al. 2012; Rigat et al. 2011; Sunwar et al. 2006; Taylor and Lovell 2015). Ornamental-dominated home gardens of Europe demonstrated even higher species diversity, with 42–112.4 species per garden (Smith et al. 2006; Vogl and Vogl-Lukasser 2003). Chinese gardens had diversity levels comparable to those of Jeju (Clarke et al. 2014; Huai et al. 2011), with similar food group compositions (vegetable dominated).

The lower diversity could be partly because of their smaller areas (approximately 0.3 ha per garden) and the absence of or insufficient structural complexity typical to the region's home gardens. Jeju villages traditionally had dense spatial arrangements of houses near sources of water, but the inter-household area has been even further decreasing (Bu 2015; Hyun 2011): in-migrating households and new developments used inter-household spaces common in other world locales (Behera et al. 2016). Additionally, a characteristic of a temperate garden (Niñez 1987), Jeju gardens rarely contained multiple vertical layers of plants.

Demographically, elderly, native, and female garden tenders were the most likely to cultivate plants in their home gardens in Jeju. The former two characteristics indicate that garden tending was being done by people who have greater connections to the traditional local culture. In addition, the contribution of a home garden in the household's cultivated land area was greater in households with elderly garden tenders than younger people. Old age often prevented garden tenders from working on their commercial farms, or they had to significantly reduce the production area, making home gardens relatively more important as a food production site. With lost or reduced income from the farm, food self-sufficiency was also more important to elderly garden tenders. The female dominance among home garden tenders supports the finding that Jeju home garden mainly operates as a kitchen garden to supply subsistence food needs from the kitchen, which has been traditionally the domain of women. Especially, there were a significant population of older women living alone in the region who rarely could meet the labor requirement needed for field agriculture. Due to a historical tragedy that killed a significant number of young men in the 1940s and 1950s (Jeju 4·3 Peace Foundation, 2014), Jeju has been called an "island of many women". Considering Jeju's older women were at higher risk of being poor compared to men of same age range (Jung 2006), the home garden's provision of food and other useful plant products could lighten the burden of the living cost for the population and augment food and livelihood security. As such 'feminization of poverty (Pearce 1978) has been a universally observed phenomenon, the home garden could also help the marginalized population around the world.

The effects of livelihood diversification on agrobiodiversity of Jeju home gardens were complex. On the one hand, agrarian traits positively affected home garden plant cultivation activity (measured by total plant abundance and plant taxa diversity). Farmers were more likely to cultivate home gardens than were non-farmers. The interview results on farmers' connecting food growing to their identity as farmers also support the positive relationship. Additionally, active farmers were more likely to have higher home garden plant diversity than inactive farmers or garden tenders without farming experience were. This finding supports the view that, to farmers, home garden tending is an extension of farming activity. In other words, it is an add-on task rather than a separate project that significantly competes over the household's time and other resources with farming activity on the commercial farms. Minimal time and resources are required to cultivate a few crops in the home garden if the garden tender and farmer are already managing crop fields. The time necessary for garden tending was especially short because the area of Jeju home gardens was small.

On the other hand, home garden plant cultivation was more important for households with more diversified sources of income in terms of areal proportion to total farmland (Section 2.3.2). Additionally, farm households with nonfarm income had higher plant diversity in their home gardens than those without such income (Regression analysis). An explanation for these findings is that households with nonfarm income tended to have smaller areas of crop fields (total farmland area) than those without. As a portion of a commercial crop field could be used as an additional subsistence production site, households with larger crop fields often did not have to use home gardens to cultivate the full range of subsistence food that the households may need. Therefore, it could be assumed that home gardens were relatively more important to farm households with smaller crop field areas. At the community level, however, communities with greater availability of nonfarm jobs (e.g., developed coastal villages, village type A) in Jeju were those with smaller inter-household areas compared to less developed villages. Such villages also held lower home garden plant diversity and abundance in the home gardens. The communities were more densely populated, reducing inter-household spaces, and had markets to supply necessities to fulfill the local home garden's provisioning role, potentially explaining the lower diversity and abundance of plants in home gardens.

Additionally, a positive statistical relationship appeared between the diversities of field crops and home garden plants. It suggests a common impetus that a household with a certain trait may want to diversify plants in their crop fields and home gardens. For example, the garden tender and farmer with a stronger risk-avoidant trait may prefer diversification as a strategy to mitigate risks of crop failure and maintain consistency in production. This personal preference can simultaneously manifest as high agrobiodiversity in home gardens and crop fields.

2.4.2 Impact of geographical location on agrobiodiversity in home gardens

The elevation of home gardens and level of development of villages were important geographical factors in Jeju in determining the cultivated plant diversity and abundance in home gardens. Higher elevation positively affected taxa richness and abundance of cultivated plants in home gardens. The elevation also positively affected traditional agrobiodiversity (the diversity of landrace seeds the households had in storage; Korea Women Peasant Association 2013). Higher-elevation (more isolated) villages tended to better preserve traditional knowledge and lifestyles (Korea Women Peasant Association 2013) and were isolated from markets. This isolation increased the necessity to cultivate subsistence food and other useful plants near homes, increasing plant diversity in home gardens.

A higher level of geographical isolation, in contrast, has been found to negatively affect agrobiodiversity in home gardens in other areas of the world. In previous studies performed in other sites (Ecuardor, India, Uganda), the higher elevation negatively affected home garden plant diversity in the study sites (Caballero-Serrano et al. 2016; Das and Das 2015; Whitney et al. 2018). The high-elevation study sites, however, were > 1,000 m above sea level (a.s.l.), unlike <400m a.s.l. of the sampled home gardens of Jeju. An explanation is that high mountain areas of more than 1,000 m a.s.l. can have lower temperatures to allow generally lower diversity of plants in home gardens and elsewhere (Fentahun and Hager 2010). However, a <400 m altitudinal difference between coastal and mid-hill home gardens in Jeju was presumably insufficient to create such climatic differences in the gardens. Thus, the mid-hill home gardens of Jeju did not receive the negative climatic effect of being on higher elevation than coastal home gardens.

Geographically isolated villages in previous research had another site-specific negative effect that was not as applicable to high-elevation home gardens of Jeju. The households of isolated villages were often also separated from sources of planting materials that were frequently located outside these locations (Ban and Coomes 2004). In areas where many planting materials were obtained from a network of fellow farmers and home garden tenders, the isolation reduced the village's home garden plant diversity (Ban and Coomes 2004; Perrault-Archambault and Coomes 2008; Wezel and Ohl 2005). By contrast, in Jeju, the planting materials for home gardens were obtained from centralized, commercial sources (e.g., market sellers) at less frequent, sporadic intervals. Thus, the social connections of a household to large networks are less important in Jeju in determining the plant diversity of home gardens, partly explaining the higher diversity of plants in higher-elevation (less-connected to networks) home gardens.

Other geographical divisions investigated in this study did not significantly impact plant diversity, abundance or composition in home gardens in most categories, including climate and soil divisions (north-south or east-west). The lack of biophysical effects on plant diversity and composition was consistent with the hypothesis because biophysical limitations such as those of soils could be improved with technological advances (Kehlenbeck et al. 2007). The soils could, however, continue to influence mediating factors such as the commercial field crops grown in the region, which could affect plant cultivation in home gardens. Composition and diversity of commercial field crops significantly differed among Jeju geographical divisions from the interview data collected during home garden visits. For example, farm households in Namwon subregion had lower commercial field crop diversity than those in other subregions as many farmers in the subregion grew only citrus. The commercial field crop diversity of the household, in turn, had a statistical relationship with plant diversity in the household's home gardens (Table 2.7). These findings demonstrate that successive links may exist among biophysics, field crops, and home garden plants.

2.4.3 Deskilling and its impact on agrobiodiversity in home gardens in Jeju

A significant disconnection between home garden tenders and traditional agrobiodiversity was observed in interview results where farmers mostly reported their dominant source of home garden planting materials as professional breeders. The interviews showed that farmers and home garden tenders in contemporary Jeju have entirely or partially abandoned their seed-saving practices and were using professionally bred materials for crop fields and home gardens. With agricultural commercialization, local farmers started using such materials for commercial production (crop fields). An unintended effect of this transition was that it also became easy for the farmers to acquire from breeders the planting materials and necessary knowledge for home gardens, which was the reason home garden tenders cited as why they transitioned to the new mode of planting material sourcing. This phenomenon, called deskilling, has been observed in other studies, where gardens have been "colonized" by planting materials from breeders (Brush et al. 2003; Gilbert 2013). The centralization of planting material sources around a few professional breeders is supported by the high idiosyncrasy of home garden plant taxa across home gardens and the lack of geographical variation in home garden plant composition across distant locations (Figure 2.5). By contrast, the peer network of planting material exchange was poorly developed in Jeju (They were not significant source of planting materials for home gardens according to interview results), unlike cases in other world locales with strong social networks that enriched home garden agrobiodiversity (WinklerPrins 2002; Ban and Coomes 2004; Perrault-Archambault and Coomes 2008; Aguilar-Støen, Moe, and Camargo-Ricalde 2009). In Jeju, by contrast, the presence of family nearby lowered the household's home garden agrobiodiversity, according to the regression result. An explanation for this finding is that rather than operating as a source of planting materials, the family network served as a social safety net for the household, reducing the household's need to make provisions such as subsistence food production.

Jeju home gardens harbored moderate but significant species (taxa)-level agrobiodiversity, but the sites' contribution to infraspecific agrobiodiversity seems not as significant because of the prevalent deskilling. However, legumes were relatively well conserved, according to the results of this study (Figure 2.4) and a landrace storage survey (Korea Women Peasant Association 2013), unlike traditional grain crops whose traditional varieties were rarely cultivated or in the seed storage in contemporary Jeju. Legumes were presumably conserved because they had versatile uses (e.g., the seeds are used as a staple and the leaves as green vegetables) and made unique contributions to the household. The food group provided ingredients for important condiments (e.g., miso paste) and traditional varieties could enhance the taste of the condiments. Thus, despite the lower yield, some superior-tasting legume varieties survived, as observed in cases on other condiment species in other world locales (e.g., Montesano et al. 2012).

Centralization of planting material sources for home gardens, however, was not an entirely negative phenomenon. First, market-bought planting materials facilitated plant cultivation in home gardens by aspiring garden tenders. For example, the interviewed young in-migrants often had no connections to local seed sources, and elderly individuals with ailments often found seed-saving too burdensome. Such populations may be unable to cultivate plants in home gardens without professional suppliers of planting materials. Although their entry to plant cultivation in home gardens in this way may not be meaningful in preventing loss of local infraspecific agrobiodiversity, it may benefit them in household food and nutrition security and other benefits of home garden plant cultivation.

2.5 Conclusion

This study's findings suggest that Jeju home gardens were primarily subsistence food gardens, especially vegetable gardens. The gardens were smaller in area and had lower diversity than tropical home gardens or the studied temperate gardens, at the taxa (species) level. However, for a large proportion of the Jeju population (e.g., nonfarmers, urban residents, and young adults), the role of home gardens as production sites has been largely delegated to food markets, where individuals purchase foods and other livelihood necessities rather than producing them. However, the food markets do not uniformly fulfill their roles in all parts or demographics of Jeju. Some locations (e.g., geographically isolated villages) had poor access to food markets, and some demographics (e.g., elderly population) could benefit from cost-saving effects of home food gardens.

The planting materials for home gardens in Jeju were mainly purchased from professional sellers, and seed-saving has become a rare practice. The exchange network for the materials between garden tenders (or farmers) was weakly developed. As a result, most of the traditional landraces were no longer being cultivated. The loss, however, had some difference among food groups: legume and seed plant landraces were generally better conserved, and traditional grain seeds were rarely saved. The centralization of planting material sources, however, positively affected plant cultivation practice in home gardens among some of the population. It lowered the entry barriers to plant cultivation in home gardens for individuals who would otherwise have had difficulty in acquiring planting materials or information on plant cultivation (e.g., new in-migrants).

At the household level, agrarian traits positively affected plant cultivation in home gardens, but some of the household traits of livelihood diversification also had a positive effect. Farmers were more likely to have cultivated plants in their home gardens than nonfarmers were. Farmers' identity as farmers was an influential motivation for plant cultivation in home gardens. However, the presence of nonfarm income and higher field crop diversity in farm households also positively affected plant diversity in their home gardens. The results indicate little competition between plant cultivation in home gardens and other labor commitments. Plant cultivation in Jeju home gardens was an add-on task that may benefit from farm work, not an independent full-scale commitment that busy farmers cannot maintain. Jeju gardens could be low maintenance because they were generally small and thus did not require too much time or labor to cultivate. In another sense, having nonfarm work may help maintain the household size amid the continued rural exodus of Jeju natives. Larger households require more food and other products from home gardens than smaller households do, potentially positively affecting plant diversity and abundance in home gardens. These findings illustrate the complex effects of livelihood diversification on plant cultivation in contemporary home gardens in an industrialized context.

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Chapter 3

Regionally divergent roles of the South Korean state in adopting improved crop varieties and commercializing agriculture (1960–1980): A case study of areas in Jeju and Jeollanamdo

3.1 Introduction

Many national and local governments, as well as international agencies, encourage the adoption of high-yielding varieties of crops (Patel 2013; Kyeyune and Turner 2016; Goto and Douangngeune 2017) and cash crops (Fu et al. 2009; Anderman et al. 2014) as rural development strategies. Entrepreneurial smallholders may also adopt improved varieties in their initiatives to better ensure their food security and enhance their quality of life (Barney 2004; Louis 2015; Rambo 2017). Examining the impact of such crops and varieties on each locale is highly relevant today, given the increasing incidence of international land grabs and the abundance of industrial tree plantations (Wolford et al. 2013; Baird 2020). One of the issues posed by cash crop adoption is the possibility that newly adopted crops may displace the food crops traditionally grown in the locale, risking the loss of the agrobiodiversity and potentially threatening the food security of the farmers that agrobiodiversity supports (Frankel and Bennett 1970; Harlan 1975; Pretty 1995). Traditional and modern (improved) crops and crop varieties can coexist, however, if they occupy different spatial, social, and cultural niches in the farming system (Zimmerer 1996, 2013; Oakley and Momsen 2005; Bellon and Hellin 2011; Olson, Morris, and Méndez 2012; Zimmerer and Vaca 2016; Tamariz 2020).

In general, the state's approach to development and natural resource management has been interpreted as coercive (Vandergeest and Peluso 1995), rigid (Scott 1998), and politically self-serving (Ferguson 1994; Li 2007) rather than serving development subjects. Yet, smallholders, rather than being passive victims, often have significant influence over the state's actions through appeals, negotiation, and resistance (Zimmerer 1991; Muldavin 1997; Wang 1997). The aims and outcomes of state projects may sometimes converge with the aspirations of smallholders and the rural and urban poor (De Vries 2007; Roth 2008; Hickey 2009). State support may also vitally help smallholder-initiated development projects (Cramb and Curry 2012). Additionally, the state's role in a specific locale's development can vary according to the locale's human and biophysical factors, from the local to the international scale (Bassett 1988;

Zimmerer 1991; Grossman 1993; Clay 2017). New development innovations also have to fit into existing local livelihoods and land uses and operate with complex social relations, including gender and class (Schroeder 1993; Rocheleau 2008; Basu 2009; Birkenholtz 2009). Such factors must be considered, as they may affect the unfolding and outcome of any development project.

Industrialized East Asian countries (e.g., South Korea) may represent one of the most understudied regions from the perspectives of nature–society geography and interdisciplinary approaches, such as political ecology (Glassman 1999; Hsieh 2011; J. T. Hwang 2016). The "developmental state" thesis has explained the role of the strong, interventionist state in enabling the region's remarkable industrial growth in the late 20th century (Johnson 1982; Woo-Cumings 1999). The strong role of the state has held true in other sectors and areas of policy intervention as well, including agriculture and rural development (Moore 1988; Burmeister 1990; Mulgan 2005; Looney 2012; Yi 2019). However, there has been insufficient research on how the role of the state and its relationship with society has affected the management of natural resources and development outcomes in the rural regions (Nam 2017). Local ecology has also not been sufficiently situated within the unique political-economic contexts in which these countries rose from "the periphery" to "the core" of the world stage within a short time.

While recognizing these gaps, this paper studies the roles of the South Korean state in the adoption of improved crops and crop varieties, agricultural commercialization, and the dynamics of agrobiodiversity in this context. This paper adopts a political ecology approach, along with the approach's classic concern for the interplay between political economy and local cultural ecology (Blaikie and Brookfield 1987). By focusing on the citrus-cultivating areas of Jeju Special Self-Governing Province (hereinafter, Jeju Province), this study investigates local farmers' adoption of improved varieties of tangerine (hereinafter, citrus) as a cash crop in the 1960s and 1970s and the gradual replacement of traditional subsistence agriculture of high agrobiodiversity with citrus cultivation. This study compares the situation in Jeju with that in the rice-growing regions of mainland Korea that adopted state-bred high-yielding varieties of rice during the Green Revolution era (1970s), replacing the previous varieties of rice. The crops' traits, as well as the characteristics of existing land use systems of each region are compared (e.g., availability and use of marginal lands such as home gardens), in addition to the Korean state's policy interventions and the political economic context of the state actions. Through the comparison, this paper analyzes how the same state adopted different approaches to introduce these two crops and to the general agricultural development of the two regions. This paper discusses how compatibility can be established between a crop and the extant local production system to ensure that the subsistence-to-commercial transition does not threaten farmers' food security.

3.2 Methods

3.2.1 Study areas and case studies

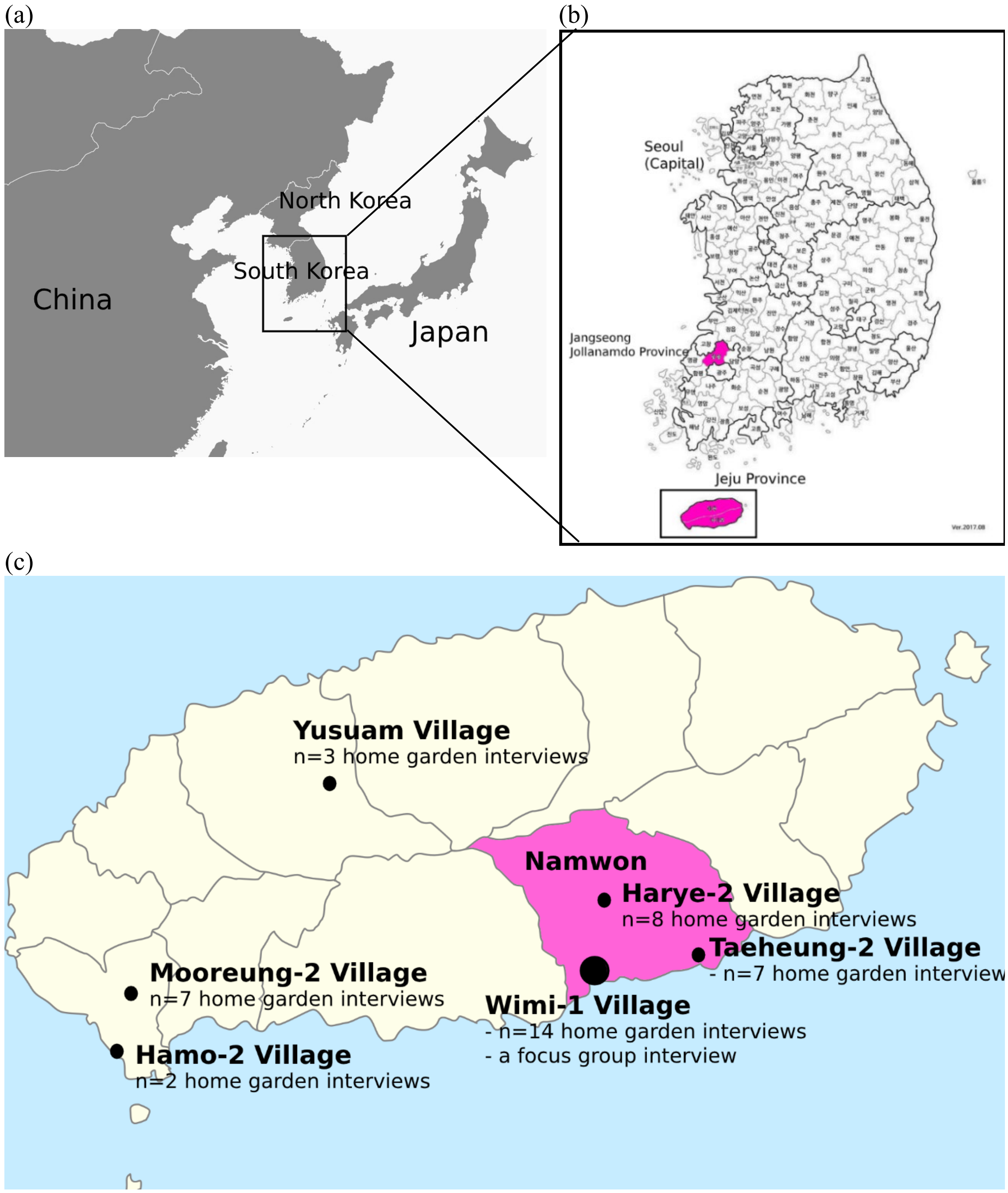


Figure 3.1: Locations of (a) South Korea and (b) Jeju Province, the primary study area, and Jangseong, the secondary study area, and (c) study villages within Jeju with descriptions of the samples

Image sources: (a) Zuanzuanfuwa (2009), (b) Modified from Hooniyooni (2018), (c) Modified from Asfreeas (2011)

The study area was located in Jeju Province, one of the nine provinces in the Republic of Korea (South Korea) (Figure 3.1), with a total area of 1,849 square kilometers. The province has a warm temperate to sub-tropical climate with soils derived from volcanic ash and the basalt bedrock. This has severely limited the province's ability to produce lowland rice, which occupies approximately 60% of all farmland area in the country (Statistics Korea 2015a). Forests and other natural vegetation make up 47% of all land cover in Jeju while farmland and pasture make up another 37%. The province's population was 605,619 at the time of the fieldwork in 2015. Mount Halla (1,950 m above sea level) creates variation in the altitudes and vegetation of Jeju, which range from the hardwood forests of the coast to the afforested coniferous forests of the high mountains.

Jeju's most prominent industries are agriculture and tourism (e.g., hospitality, transportation). The region's tourism industry, which is mainly nature-based, has been booming, recording approximately 15 million visitors per year since 2015. Agricultural land use in the province has likewise undergone a drastic change, from being dominated by subsistence agriculture in the 1970s (e.g., barley, foxtail millet, and legumes) to fruit (predominantly citrus) and vegetable (e.g., Asian radish, cabbage, and garlic) production for the market in the 2010s. The cultivation of cash crops, especially citrus, has successfully increased rural income since the 1970s. Fisheries and animal rearing (e.g., cattle and horses) have also contributed to the livelihoods of some Jeju households and are now highly commercialized and specialized. The interview data for this study primarily came from three villages (Wimi-1, Harye-2, and Taeheung-2) in the Namwon sub-region of southeastern Jeju (Figure 3.1 (c)), one of the regions where citrus agriculture is most intensive.

This paper also examines the role of the South Korean state in controlling the production and varietal diversity of rice during the 1970s, drawing on national-level records and research. At the county level, Jangseong was chosen as a secondary study site (Figure 3.1 (b)). The county has published a detailed local agrarian history as well as yearly production statistics of popular rice varieties in the county. Jangseong is a midsized (519 square kilometers) rural county in Jeollanamdo Province. Its population count was 42,058 as of 2015, which had dropped drastically from 114,345 in 1970 (Statistics Korea 1970b, 2015c) through the exodus of the younger generation to the cities. As of 2015, mountainous forest and natural vegetation comprise 62% of the county's area, followed by 23% farmland and pasture (Ministry of Land, Infrastructure and Transport 2015). Of the farmland in Jangseong, 54% (11,152 ha) was devoted to lowland rice, which had also dropped from 62% in 1970 (Statistics Korea 1970a, 2015b).

3.2.2 Data collection and analysis

Primary field data were collected in Jeju from June through August 2015. The author made home garden visits (n = 131) to create a cultivated-plant inventory for each garden and to interview the garden tenders. Eighty-nine garden tenders were actively farming land other than home gardens, and forty-one of these were cultivating commercial (improved) citrus at the time of the visit. The locations of the 5 villages where the 41 tenders lived are shown in Figure 3.1 (c). The tenders provided the characteristics and management details of their garden, farm (e.g., list of crops cultivated by the household that year), and household. Tenders who were citrus farmers provided the then current status and history of their citrus production. In March 2016, a follow-up focus group interview was conducted with four village elders in the Wimi-1 village. The focus group interview provided details of when, how, and with what resources Wimi farm households had initiated and managed this transition. Background information was gathered by interviewing local researchers specializing in traditional agriculture and retired or incumbent government officials involved in agricultural policymaking and farmer advising. These interviews provided information about traditional production systems, the citrus adoption process, and the general agricultural transition of the 1960s and 1970s.

Government statistics from Statistics Korea provided demographic and agriculture-related data at the national, provincial, and sub-regional (eup, myeon, and dong) levels. Articles in regional newspapers (e.g., Headline Jeju) also provided information on traditional agriculture, new crops, and the nature of the transition. Village-level citrus adoption accounts were also gathered from government-published sources featuring rural villages and other entities (e.g., schools) that had successfully increased their household income through development efforts (Table 3.1). These success stories were published by the New Village Movement (NVM; Saemaul Undong), a campaign-style rural modernization program promoted to Korean rural villages by the government under President Park Chung-hee (in office 1963–1979) 1971 onward. NVM's objective was to "build rural communities with high income and living standards by overcoming elements of rural backwardness (…) and by monumentally increasing income (Table 3.1, Source number 1)." These sources complemented the field interviews to elucidate the citrus adoption and agrarian transition processes in Jeju by providing other villages' accounts from an earlier period of citrus adoption.

Table 3.1: Sources (n = 11) of case studies of Saemaul Undong (New Village Movement) that featured citrus adoption stories in Jeju villages (all are in Korean)

No.	Year	Publisher	Publication	Sub-region in Jeju	Village (or school)	Pages (Number of pages)	URL
1	1973	Ministry of Home Affairs	Saemaul Undong: from the start to this day 1973	Seogwi	Shinhyo	397–407 (11)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001287874
2	1975		Saemaul Undong: from the start to this day 1975	Seogwi	Seohong	409–418 (10)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001287814
3	1975		Saemaul Undong: from the start to this day 1975	Namwon	Wimi Elementary School	445–452 (8)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001287814
4	1976		Saemaul Undong: from the start to this day 1976	Pyoseon	Gashi	491–502 (12)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001287709
5	1977		Saemaul Undong: from the start to this day 1977	Namwon	Wimi-2	387–394 (8)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001287871
6	1978		Saemaul Undong: from the start to this day 1978	Hanrim	Geumak	405–412 (8)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001287872
7	1979		Saemaul Undong: from the start to this day 1979	Aewol	Yongheung	385–394 (10)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001287873
8	1977	Ministry of Agriculture and Forestry	Saemaul income growth success cases: Volume 7	Jeju-City	Doryeon-1	91–98 (8)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001291017
9	1977		Saemaul income growth success cases: Volume 7	Jocheon	Daeheul-1	99–106 (8)	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001291017
10	1978		Saemaul income growth success cases: Volume 8	Namwon	Harye	283–294	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001291014
11	1979		Saemaul income growth success cases: Volume 9	Jeju-City	Nohyeong	264–274	http://theme.archives.go.kr/viewer/common/archWebViewer.do?archiveId=0001291016

The Korean Green Revolution, especially the adoption of government-developed improved rice varieties (known as Tongil-style varieties), has been well-studied (e.g., Burmeister 1987, 1988; T. H. Kim 2017). Thus, this paper's background information about the development and propagation of these varieties was drawn mainly from secondary sources, including books and articles on agricultural history (e.g., T. H. Kim 2017). Newspaper articles from the 1970s through the 1990s are available online (e.g., Joongangilbo archives) and were used to collect statistics, policies, and farmers' responses to the policies of the time. Government statistical records, including crop production survey results, provided national and province-level information on changes in rice yields and cultivation areas, among other things. For county-level information, this paper referred to a 2001 publication on the local history of Jangseong (Jangseong County History) for information on rice cultivation areas and yields and the most commonly cultivated rice varieties in the county (1960–2000).

3.3. Results

3.3.1 Agrarian background and agricultural policies of South Korea in the 1970s

South Korea transitioned from a traditional agricultural economy to an export-oriented industrial economy mainly during the 1960s and 1970s—a shift that resulted in tremendous GDP growth; GDP per capita increased from 64 USD in 1955 to 28,723 USD in 2015. The country's agricultural sector, however, remained relatively stagnant in the 1960s (W. Kim 2019). Since the land reform of 1950, Korean agriculture has remained smallholder-dominant (with the majority holding less than 1 ha of land) and owner-operated (Rigg, Salamanca, and Thompson 2016).

Two overarching agricultural strategies have been central in post-Korean War (1953–) South Korea: food production growth and general rural development aimed at increasing income and living standards (Brandt 1979; Boyer and Ahn 1991; Francks, Boestel, and Kim 1999; Kim and Sumner 2006; Kim et al. 2012; T. H. Kim 2017, W. Kim 2019; Francks 2002; Korea Rural Economy Institute 1999). To promote food production growth, the government operated state grain reserves to minimize price fluctuations (1961–). The purchase and release prices were set to ensure both affordability to customers and profitability to producers through a "double grain price policy (Ijunggokgaje)" (1969–1997) (National Archives and Records Services 2011b). In addition to these price policies, the state made direct intervention in staple production (Burmeister 1987; Kim and Sumner 2006).

Amidst this intervention was the scientific breeding and promotion of high-yield rice varieties, along with other agricultural modernization efforts (e.g., the use of chemical fertilizer). Korean farmers had begun cultivating modern (scientifically-bred) grain varieties during the period of the Japanese colonial rule under government promotion (Kim et al. 2012). Modern varieties of rice were cultivated in 86% of the total area under rice production in Korea in 1936, although this number had been only 5% in 1912 (T. H. Kim 2017). Accordingly, most of the

1,451 traditional Korean landraces of rice were lost (Agricultural Model Farm 1913; T. H. Kim 2017). Landraces or farmer varieties are defined as crop varieties that have been cultivated in the farming system for a relatively long period (e.g., more than one generation) and that are farmer-selected and often adapted to the local environment (Harlan 1975; Zeven 1998; Cleveland, Soleri, and Smith 2000; Villa et al. 2005; Zimmerer 2010; Calvet-Mir et al. 2011).

Another pivotal policy that profoundly affected Korean farmers' production choices was a protectionist trade policy enabled by the Act on Prohibition against Selling Specific Foreign Goods (Teukjeongoeraepumpanmaegeumjibeop; hereinafter , "the Act") enacted in 1961 and remaining in force until 1982. The Act prohibited sales in South Korea of imported items that were deemed non-essential. Its aim was to foster the development of budding domestic industries. Fresh fruits were among the banned items, along with beverages, pantry foods (e.g., cooking oils), fabrics, cosmetics, and other goods. The policy boosted the prices of domestically produced fresh fruits, including the Jeju citrus.

Moreover, state-led rural development policies operated to improve rural environments as a means of enabling production growth (W. Kim 2019). The NVM discussed in Section 3.2.2 was one such rural development policy. The NVM followed the previous policies' goals of promoting rural modernization and income growth (W. Kim 2019). Through the NVM, the state encouraged rural people to build infrastructure, including roads for their villages, and modernize their living environments (e.g., residential housing) with some financial support from the state. The NVM also sought to increase rural income by encouraging farmers to adopt income projects (B. J. Hwang 2011).

3.3.2 Grain production systems of South Korea: Cases of paddy rice and other major grains

3.3.2.1. Rice in mainland Korea: Consumption and production of rice, agrobiodiversity, and the role of the state

Rice production has been the mainstay of mainland Korea's food consumption and production. Rice has traditionally been the most preferred staple food in the country, contributing more than any other food to the nation's calorie intake until the 1990s (Yook 2017). Even in regions biophysically unsuitable for lowland rice cultivation (e.g., Jeju, Gangwon), local people still consumed rice as a "premier food" for special occasions. Because of its popularity, rice has also been the default crop choice among farmers for both commercial and subsistence purposes. In 1970, 81% of all farming households and 36% of all households in South Korea were rice cultivators (Statistics Korea 1970a). Of all the rice produced in South Korea, 63%–74% was put up for sale, while the rest (26%–37%) was consumed for subsistence between 1969 and 1975 (Ministry of Agriculture and Forestry 1978). Even after dietary changes that lowered the importance of rice to include other food groups (e.g., meat and vegetables), the proportion of farming households growing rice has remained relatively high (59%) (Statistics Korea 2015b). One reason for this is the enduring state support for rice cultivation (McMichael and Kim 1994), including direct payments, even after the Uruguay Round of the General Agreement on Tariffs and Trade in 1994 undermined the basis for the state's protectionist policies over its agricultural sector.

An earlier state intervention in rice agriculture was the direct promotion of the state-bred improved varieties from 1971. By 1970, scientifically-bred varieties had already mostly replaced traditional farmer-bred varieties (Section 3.3.1). These improved rice varieties were still notably different from the pre-1971 varieties. The first of the newer rice varieties was called Tongil and was followed by 39 Tongil-style varieties (e.g., Yushin and Nopung) bred using similar breeding techniques (Kim et al. 2012). Tongil was initially bred in the late 1960s by Korean state scientists at the International Rice Research Institute using the IR-8 variety as the parent (Ministry of Agriculture and Forestry 1969). IR-8 was one of the "miracle rice" varieties of the Green Revolution because of its high-yield capacity. As IR-8 was an indica-subtype rice variety suited for tropical environments, the variety itself did not grow well in temperate countries like South Korea. To solve this problem, Korean state scientists created Tongil (IR-667) by hybridizing one indica variety (IR-8) with two varieties of japonica-subtype rice that had long been cultivated in temperate East Asia (Kim et al. 2012).

Tongil-style varieties differed from pre-1971 varieties in the following ways. First, its yield was about 17%–21% higher than that of existing varieties (japonica–japonica hybrids) (National Archives and Records Services 2011c). Hybridizing japonica with indica solved japonica's persistent issue of lodging and increased blast resistance and fertilizer tolerance. As a result, Tongil-style varieties could achieve much higher yields in the earlier years of planting. Second, the interval between the completion of breeding and widespread farmer adoption was reduced (T. H. Kim 2017). Whereas the pre-1971 modern varieties typically took over a decade between breeding and large-scale cultivation, the new varieties took only a few years. For example, Tongil was bred in 1966 and was cultivated nationwide by 1971; for Nopung, the interval was even shorter, from 1976 to 1978 (Joongang Ilbo 1978a, 1978b). On the contrary, Paldal, one of the pre-1971 modern varieties, was bred in 1933 and not popularized until 1944. The percentages of area under Tongil-style varieties were 36.9% and 76.2% in 1975 and 1978, respectively (Joongang Ilbo 1975; Kim et al. 2012). In Jangseong, the percentage of area under Tongil cultivation reached 94% of all rice fields in 1977. In addition to emphasizing the merits of these varieties, the state also led comprehensive changes to the production system, from technical improvements (e.g., irrigation) to policy-level facilitation to realize the varieties' high-yield potential (T. H. Kim 2017).

After four years of Tongil-style planting, in 1975, the state government declared that South Korea had finally achieved national grain self-sufficiency (C. Park 1976). This meant that South Korea was producing enough staple crops (e.g., rice, barley, and soy) to meet the population's nutritional requirements. The adoption of high-yield varieties also improved farm economies at household and community levels; it reduced the number of farm households with (periodic) food shortages (T. H. Kim 2017), increased farm income, and in some cases, alleviated farm debts (Korea Rural Economy Institute 1999).

Nevertheless, many farmers found the Tongil-style varieties too unappealing for consumption, costly, and risky to cultivate on a large scale (National Institute of Korean History 2009; T. H. Kim 2017). The taste and texture of Tongil-style varieties resemble indica rice rather than japonica rice. The typical indica taste and texture (fluffy) did not appeal to Korean consumers who traditionally preferred moist and sticky rice. Thus, even the farmers who produced Tongil-style for sales cultivated japonica for their own subsistence (T. H. Kim 2017). Consequently, Tongil-style rice also had a lower market price than japonica rice (as much as 50% lower) in the private market (R. Park 2014). Additionally, the production costs of Tongil-style varieties were typically higher as these varieties needed heavier application of chemical fertilizers and pesticides (Gwon 1974) and heated germination beds (Kim et al. 2012). Furthermore, some Tongil-style varieties turned out to be unstable, being very vulnerable to cold damage (Joongang Ilbo 1972b). To many farmers, these shortcomings overpowered the benefit of a higher yield.

The economics of Tongil-style rice production were therefore not sufficient to motivate a large number of farmers to adopt Tongil varieties. The state had to employ other measures to achieve the national Tongil-style adoption goal, which was that 67% of all rice areas would be planted with Tongil-style rice by 1977 (Joongang Ilbo 1977). The state therefore purchased Tongil-style rice at a favorable price by means of the double grain price policy until the early 1990s (T. H. Kim 2017). Government officials also used force to urge farmers to cultivate Tongil-style rice and discourage them from japonica cultivation (e.g., by destroying japonica germination beds) (R. Park 2014; Choi 2016; T. H. Kim 2017).

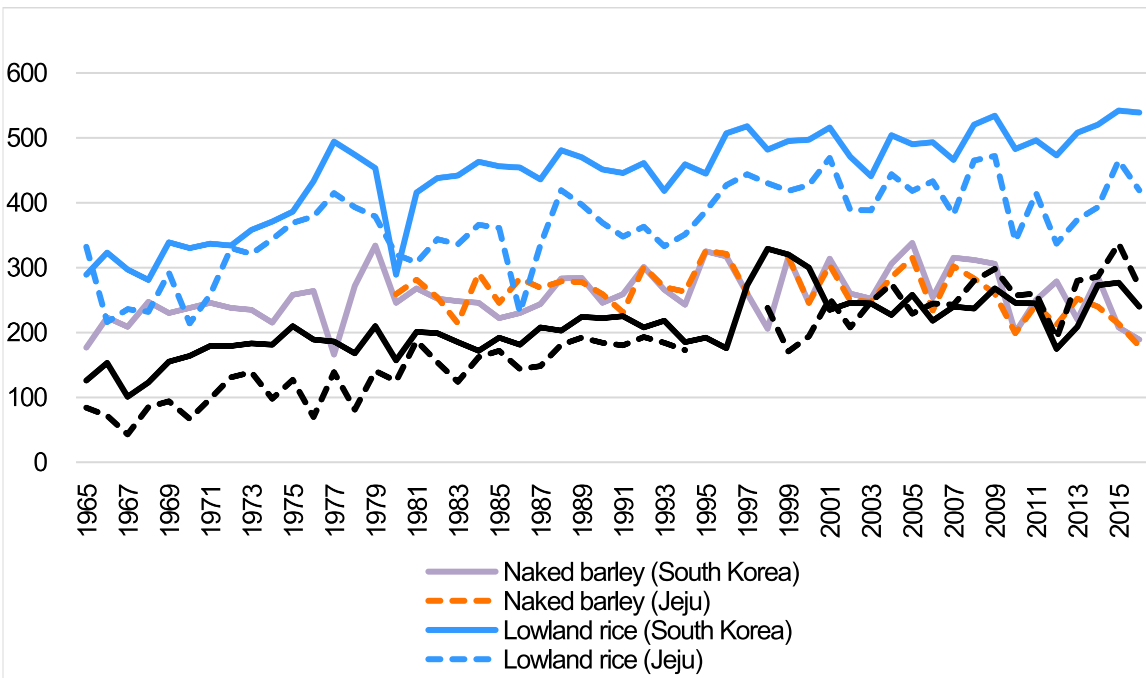
Tongil-style varieties' shortcomings became highly apparent in the late 1970s, and its production significantly decreased in the 1980s and 1990s. For example, approximately 60,000 ha

(35.3%) of the 170,000 ha under Nopung production were lost to blast in 1978. This nationwide failure undeniably contradicted the state's claim that Tongil-style rice had high blast resistance. Farmers started to seriously doubt the state's ability to advise them and began protesting against forceful state intervention (Jangseong County History Compilation Committee 2001; Choi 2016). The media also criticized the state's forceful approach and the short testing period of the varieties (Joongang Ilbo 1981). Additionally, the new varieties had been encouraged in all rice-growing regions, except for the colder northern regions, without considering biophysical differences between them, for example, highlands and lowlands (Joongang Ilbo 1981). The state initially responded to this criticism by prohibiting the intensive monoculture of one variety (Joongang Ilbo 1978c). After the authoritarian regime collapsed, the new government employed a more liberal approach toward agricultural issues, including rice variety choices (Cho 2004). Korean consumers had also begun consuming comparatively less rice, as their diets had westernized, lowering rice demand. The state consequently moved away from the double grain policy, which had in any case been too expensive to sustain. Without the state applying force or incentives, farmers ceased to cultivate the unpopular Tongil-style varieties.

Another downside of the promotion of the Tongil-style varieties was that the state policies did not consider the relationship between rice cultivation and other livelihoods at the local level. Rice cultivation in each locale had to meet requirements that were not directly related to yield. Farmers had to consider other livelihoods that would potentially be affected by their varietal choice. While the state may have been concerned solely with the superior grain yield of a variety, farmers' criteria were more complex. In the southern regions, for example, rice has been largely double-cropped with other crops (e.g., barley). Double cropping inevitably requires the cropping schedules of the two crops to be coordinated with each other. Tongil-style seedlings (May transplanting) have to be transplanted earlier than japonica seedlings (June transplanting), which made it impossible for many Tongil-style varieties to be intercropped with barley, which is harvested in June (Y. Kim 2020). Thus, cultivating Tongil-style rice created an opportunity cost precluding barley production (Joongang Ilbo 1972a). In Jangseong, the production of japonica rice and barley combined amounted to 440 kg/1,000 m^2 in 1965 and 541 kg/1,000 m^2 in 1970, which was comparable or superior to the 485 kg/1,000 m^2 average yield of Tongil-style rice between 1971 and 1980 (Jangseong County History Compilation Committee 2001). Having multiple yields throughout the year offered the additional benefits of balancing out seasonal food shortages and mitigating the risk of a crop failure threatening the household's entire livelihood that year.

In addition, traditional rice cultivation supplied other livelihood necessities needed for the household and additional income that Tongil-style rice failed to provide (T. H. Kim 2017). The straw of rice served as both crafting material (e.g., for ropes and roofing material) and fodder for household animals. Tongil-style varieties, however, were bred to have shorter stems (about two-third the length of japonica stems) to prevent lodging. These shorter stems resulted in straws that were not long enough to make ropes of the desired width. In addition, household animals did not like the taste of Tongil-style straw. Thus, Tongil-style rice farmers often had to purchase such goods from the market, which resulted in extra costs (T. H. Kim 2017). The unsuitability of Tongil-style rice varieties thus made these varieties' cultivation not only difficult but also economically disadvantageous.

3.3.2.2. Jeju's traditional crops, commercialization, and agrobiodiversity impacts



Data note: Naked barley data (Jeju) between 1965–1980 was missing from the archive

Figure 3.2: Changes in the average yield (kg/10a) of major grains in South Korea (solid lines) and Jeju (dotted lines) (1965–2018). *Data source:* Statistics Korea (1965–2016)

For several centuries until the 1970s, Jeju's main staple crops were barley and millet, planted in rotation (Hisama 1950; Ko 2018; Lee 2020d). Minor food crops included legumes, buckwheat, upland rice, and sweet potatoes. Figure 3.2 shows the yield of major grains in South Korea (average) and Jeju over the years, including the 1970s and 1980s. Both the types of rice had superior yield in South Korea than in Jeju until after 2000 because of Jeju's biophysical limitations. Although the barley yield in Jeju later converges with upland rice yield in the region, barley was approximately 1.5–2 times more area-efficient in Jeju until the 1990s. Upland rice also had higher labor requirements compared to other grains in Jeju (Ko 2018). Lowland (paddy) rice had a superior yield, but it occupied minimal area due to the region's soil limitations. Thus, rice had a rather insignificant presence in Jeju farming systems, although the grain had high consumption value.

Non-subsistence agriculture started in Jeju during the period of the Japanese rule and has been the dominant form of agriculture since the 1960s (Lee 2020a). The colonial government required Korean farmers to supply Japan's military with necessities (e.g., industrial-use sweet potatoes) (Lee 2019). After the liberation, farmers started cultivating significant areas with commercial crops, such as canola and sweet potato, for their own profit (Lee 2019). Citrus fruits emerged as the next popular commercial crop, coming to occupy approximately one-third of Jeju's farmland area by 2015 (Statistics Korea 2015a). The 1980s onward, the area under vegetable cultivation increased, as domestic demand rose. These commercial crops gradually replaced traditional subsistence crops, such as barley, foxtail millet, and other grains and legumes.

Commercialization drove the erosion of traditional crop diversity. As subsistence agriculture decreased, so did the intra- and inter-specific diversity of traditional subsistence crops. Five main varieties of barley and twelve of foxtail millet were traditionally cultivated, according to Ko (2016). According to a 2012 survey, however, the majority of Jeju households did not report possessing any landrace seeds, and only three varieties of barley and five of millet remained in small accessions across all of Jeju (Korea Women Peasant Association 2013). Grains occupied under 1% of all accessions in the survey, while the landraces of legumes, vegetables, nuts, and seeds were relatively well-conserved.

3.3.3 Citrus in Jeju: The start of smallholder commercial crop cultivation in general and improved citrus cultivation in Jeju (1960s–)

Two other crops preceded citrus as major commercial crops in Jeju (Lee 2020b). Canola (a winter crop) and sweet potato (a summer crop) once occupied over 10,000 ha (approximately one-fifth) of Jeju's farmlands. Improved canola was introduced by Japan in the 1950s as an oil crop. Protectionist trade policies (e.g., the Act) prohibited the import of cooking oils and oilseeds, which raised the profitability of domestic canola production. The sweet potato was another earlier commercial crop; it was cultivated to produce military fuel and commercial starches during the colonial period (Dongailbo 1938) and was also popular as a food crop. Canola and sweet potato eventually lost popularity because of decreased profitability. Yet, these early commercial crops gave Jeju farmers their first experience of commercialization that paved way for later commercial crop adoptions (Susan-2-ri 1999). The crops were annual crops that needed relatively small time investments. Moreover, both the crops could be double-cropped with existing crops, including barley and foxtail millet (Mun 2010). The farmers could thus secure some traditional crop production and were amenable to the adoption of canola and sweet potato. Additionally, in many cases, the experience left the village with new infrastructure and funding resources, which could be utilized for later commercial crop production.

Citrus became the next popular cash crop across Jeju in the 1960s and 1970s. While the history of citrus cultivation in Jeju goes back to the fifth century, the commercial production of improved unshiu citrus started in the colonial period (The Citrus Museum 2005). From 1954, young plants of improved varieties (Miyagawa, Hayashi varieties) were commercially imported from Japan on a large scale (Jeju Special Self-Governing Province Citrus Marketing and Shipping Association 2006). In the 1960s, Jeju migrants to Japan began sending young citrus plants as gifts (or merchandise) to Jeju as a form of financial support for their families and neighbors in their homeland. Approximately 3.4 million plants were sent between 1961 and 1970 (Jo, Kang, and Oh 2017). Citrus was popular because of its exceptionally high returns. The crop was nicknamed “the college tree” in Jeju, implying that the sales from a few trees could pay for a child’s college tuition (Jeon 2015). The citrus-farming area in Jeju consequently jumped from less than 100 ha in the mid-1960s to 9,056 ha in 1975 (Statistics Korea 1975) and peaked at 25,190 ha in 2000, before declining due to decreased profitability.

The success of citrus introduction was based on underpinning policy contexts that enabled such high returns. One such policy was the aforementioned Act (Section 3.3.1). With the economic growth, the fruit consumption of South Koreans rose rapidly. Citrus, especially, has emerged as the most abundantly consumed fruit by weight (C. J. Park 2015). As Jeju was the only region in South Korea that had the climate to produce citrus of competitive quality on an industrial scale, the region stood to benefit the most from the newly rising consumer demand. The ensuing price spike motivated Jeju farmers to adopt the crop (the NVM success story, Source 1). Additionally, President Park made a special remark on Jeju in 1964, stipulating that Jeju farmers were to be excluded from the national drive for food production growth (because of the region’s unsuitability for rice production) (Lee 2020c). The ensuing state programs provided money and initiative for willing farmers to start new stands of citrus across Jeju (The Citrus Museum 2005; Lee 2020c). The state also made legal provisions (e.g., modification of Seeds and Seedlings Act) to allow easier and cheaper imports of the young plants from Japan (Jo, Kang, and Oh 2017) and established infrastructure (e.g., roads) to reduce transaction costs for smallholder citrus production (G. Hwang 2012).

By converting subsistence fields to commercial citrus stands, smallholders risked food security. Smallholders had to secure a portion of their land for subsistence production, which was essential for the household's yearly food provision (focus group interview). Farm households with relatively large landholdings were thus freer to pursue citrus production as an income opportunity (Figure 3.3 shows that Jeju farm households with larger total farmland were more likely to be growing citrus). By the time Wimi considered starting its first commercial citrus stands (early 1970s), Wimi villagers had already heard of the success that other villages had enjoyed with citrus and were eager to follow. However, the village households at the time could not afford to fully convert their production from subsistence fields to citrus stands. Only the wealthier Wimi households (<10%) could do so within the first 10 years. Most of the households took 20–30 years. These households gradually expanded their citrus stands using the financial and other resources they obtained through their initial citrus sales. The slow rate of transition eased the competition between citrus and subsistence crops for the limited farmland to some degree.

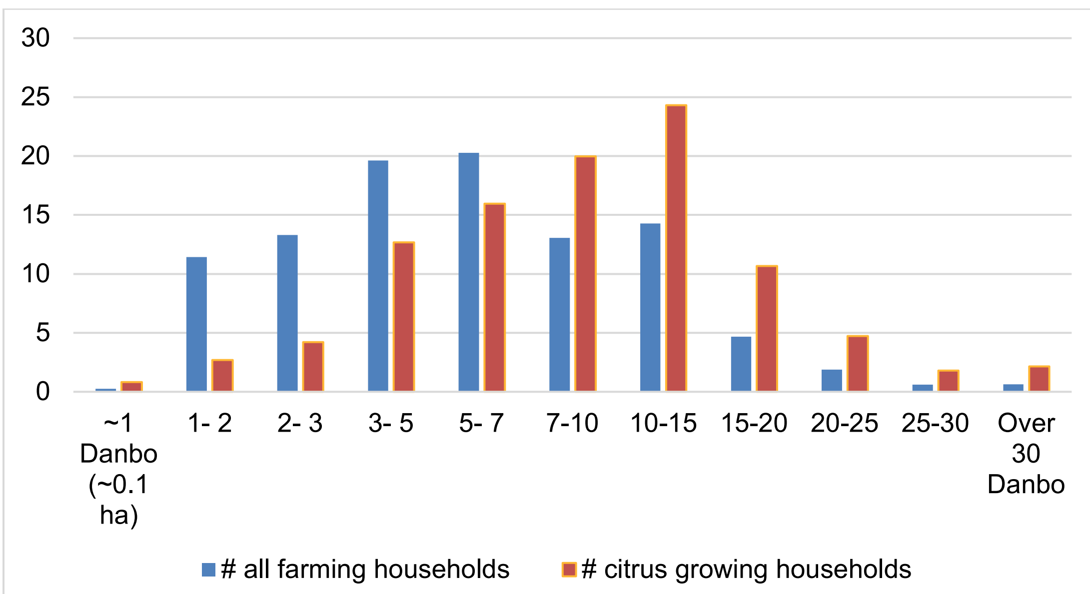


Figure 3.3: Distribution of the numbers of all farming households (blue) and citrus growing households (orange) by the total area of landholdings in 1970. *Data source*: Statistics Korea (1970a)

(a)
(b)
(c)

Figure 3.4: Wimi village citrus plantings occupying inter-household spaces in 2013: (a) a tree next to the house (b) a home garden-turned citrus stands, and (c) a land that includes a citrus stand in the upper layer and a vegetable garden in the lower layer.
Image source: Daum Roadview online street image service; http://local.daum.net

Additionally, farmers typically started their citrus stands from a few young trees on marginal lands, rather than clearing full-sized subsistence fields to plant full stands of trees. The marginal lands used included the margins of subsistence fields or inter-household spaces, including home gardens (Figure 3.4 (a), (b)). Furthermore, citrus trees did not necessarily exclusively occupy the land where they were planted. Young citrus trees did not have large crowns and thus did not significantly block the reach of sunlight to the lower-strata crop plants.

Thus, they were often planted alongside staple crops in crop fields and vegetables in home gardens (Figure 3.4 (c)). Such intercropping practices helped minimize the spatial conflict between subsistence crops and citrus stands in Jeju.

Additionally, starting in the 1960s, some semi-croplands became available for citrus stands, mainly due to agro-technological modernization and NVM-related rural transformation. In Jeju's traditional land use systems, managed grasslands provided livelihood necessities, including fodder for cattle (Ko 2018). Cattle provided manure and workforce for Jeju agriculture. The grasslands produced hay for winter while forests and other grasslands provided pasture for summer grazing (Ko 2016). Farmers also managed other grasslands that provided materials for traditional thatched roofs, which had to be replaced regularly with new grass (Ko 2016). In the mainland rice production system, rice fields typically provided straw that served as livestock fodder and roofing material. Thus, rice farmers rarely needed separate lands to supply straw. In Jeju, in contrast, the straws of barley and millet were not used for these purposes, and farmers had to maintain dedicated grasslands to provide these materials. Modernized agriculture, however, eliminated the need for animal labor: chemical fertilizers and machinery provided the services that animals fulfilled (Korea Rural Economy Institute 1999). Additionally, as a part of the NVM, the state promoted the installation of permanent asbestos roofs in place of traditional thatched roofs to modernize rural residential housing (Figure 3.5). These new roofs no longer required regular grass harvests. Therefore, the managed grasslands of Jeju lost their purposes around the same time that citrus was being introduced. Ko (2016) reports that prior to modernized agriculture, about 30%–34% of sampled households' landholdings had been dedicated to fodder cultivation and 10%–13% to roofing material cultivation. Such lands were components of the Jeju landscape that disappeared or diminished from the 1960s through the 1980s. These lands could thereafter be devoted to creating citrus stands and easing the pressure to convert subsistence fields.

Figure 3.5: Traditional Jeju houses with thatched roofs (left) and NVM-style modern housing with permanent roof (right). *Image source:* Ministry of Home Affairs (1981)

“Wastelands” were another type of land converted to citrus stands in the 1960s and 1970s in Jeju (Figure 3.6). As farmers without sufficient spare land could not afford to clear subsistence staple fields to create citrus stands, they purchased lands previously deemed inarable to create new stands. The NVM success stories describe farmers developing “woodland and wildlands (Table 3.1, Sources 2, 5, and 7)” or “barren, deserted land filled with rocks (Table 3.1, Source 3 and 10)” and “low-fertility land of volcanic ash soil (Table 3.1, Source 1)” into citrus stands with household labor. Jeju’s lowland area had abundant forests, woodlands, coppices, and scrublands tangled with woody and other plants on rocky lands that were left undeveloped (Kwon 2011). Soils of such lands were especially rocky, such that it took immense manual effort to develop them into agricultural lands (Kwon 2011). Citrus was a relatively easy-to-cultivate crop that could grow in such lands with lower fertilizer demand compared to grains like barley. The state did not make significant development intervention in these lands, although it devoted significant resources to afforestation and cropland development projects in other regions during the same era (National Archives and Records Services 2011a). Likewise, the local people had not paid much attention to the land’s development potential before the citrus boom created land scarcity. The 1970s onward, however, when the locals realized their pressing need for new land to make citrus stands, a significant portion of wastelands was eventually developed. The anticipated benefits of citrus production provided enough motivation to make farmers take on the costly task of wasteland development.

Figure 3.6: Jeju citrus stands on cleared forest along with a remaining forest patch (on the right) and a grassy area (front) that could produce fodder or roofing material. *Image source*: Ministry of Home Affairs (1982)

3.4 Discussion

3.4.1 Intervention of the Korean state in rural development by crop and region

The South Korean state approached staple and non-staple crops differently in creating and pursuing agricultural policies in the 1970s. Although the state's general policy direction was consistent (e.g., promoting commercialization and technological modernization), it employed a generally more interventionist approach to staple-crop production. This difference was especially prominent in the state's approaches to farmers' choices regarding agrobiodiversity and the adoption of improved crop varieties. Development efforts related to staple-crop production, especially that of rice, received more human and non-human resources. Also, intervention intended to increase the adoption rate was more strongly state-initiated and controlled and often more forceful. Attempts to introduce improved varieties of non-staple crops, on the contrary, received fewer resources and intervention from the state in general. Although the state did create large-scale market contexts (e.g., trade policies), it did not make much direct change to farmers' actual decisions. Farmers, in general, could freely opt out of the programs that the state promoted. Non-staple-crop adoption was also largely smallholder-initiated. In Jeju, farmers were already adopting and expanding the area under improved citrus production when the state introduced financial support programs for citrus farmers. The state's role here was mainly to assist an ongoing adoption, rather than implementing it.

Not only did state intervention in agriculture differ based on crop type, but it also varied regionally. In other words, the state intervened more heavily in farmers' decisions in what were considered high-productivity regions or regions whose natural resources were easy to tap. Rice productivity differed significantly among Korean regions; the rice paddies of Jeollado and Gyeonggido could traditionally produce surplus rice to feed populations outside these regions, while the low-fertility rice fields of Jeju could barely produce subsistence amounts. Jeju's productivity of other grains was likewise not high enough to "feed the nation." Notably, the state's cropland development efforts, as well as its encouragement of improved varieties, were concentrated in regions where productivity was already high.

The rocky soils of Jeju were not a resource that the state considered easy to access or use. Until the citrus price spike, the Jeju forests and wild lands had high expected development costs and a low expected return, if the lands were to be developed into traditional barley–millet fields. Additionally, compared to the mainland forests located in colder climate, Jeju's forests were composed of significantly different, warm temperate species, whose use was largely unknown to mainland people. In other words, Jeju had a high "friction of terrain" (c.f. Scott 1998), a term that

Scott introduced to describe particular areas that are tougher for development agents to access or comprehend (e.g., dense forests). The state's inability to understand and access certain areas inhibited its ability to advance into these areas for development, while its low view of the region's productivity lowered its motivation to do so (See de L.T. Oliveira 2013 for how the state's view of the region affects development policies). The state thus could and would not easily apply the standard measures for development (e.g., reclamation) in Jeju as in mainland regions. The result was that a large proportion of Jeju's lower-altitude forests and agricultural lands remained untargeted by state objectives.

This state under-involvement allowed for greater autonomy among farmers to make farm decisions. This autonomy was crucial to making field-relevant agricultural decisions. Farmers were free to choose whether to adopt certain crops or crop varieties as well as to set the scale and pace of any adoption. Jeju's case contrasts with the Korean Green Revolution during the 1970s. Rice farmers were subject to forceful government intervention pushing them to cultivate Tongil-style varieties. Even without this intervention, many farmers would have been willing to consider adopting new varieties, but few would have been foolhardy enough to immediately convert all their rice fields to a new variety, given the risks that accompany such rapid conversion. The state's and farmers' interests thus converged with regard to the macroscopic goal of rice production growth, but the state's goal of achieving a certain adoption rate of a fixed set of varieties within a certain time frame conflicted with the farmers' desire to minimize risks associated with any new adoption. The rapid forced adoption of Tongil-style rice as a monoculture did not allow farmers to carefully experiment with the varieties to lower the risks.

In such rural developments and associated agrarian transformations, it was not only field agriculture that the Korean developmental state transformed. Although out of the state's scope for development, home gardens also have undergone changes amid rural developments, while maintaining significant continuities. The state did not intentionally intervene in home garden plant cultivation of rural households, as home gardens were small and did not have much value to achieve the nation's food production goals. Home gardens could maintain their identity as subsistence food production sites, especially that of vegetable production. At the same time, as they were free from direct state interventions, home gardens were used as necessary to meet new subsistence and commercial production needs of the household that arise from changes to the traditional land use systems. They were used to produce subsistence foods to ameliorate food insecurities arising from the reduction of traditional subsistence fields, while also providing space for cash crop production without sacrificing subsistence crop fields for other households. Also, home garden space and plant cultivation practices received significant influence from livelihood and lifestyle changes that came with the rural developments. During the modernization campaigns of NVMs, homes were transformed into modern (western) housings, which typically reduced space in homestead available for home gardens. Planting material management practices, in general, were also modernized and centralized around professional breeders, who were often state-affiliated as seen in Tongil-style rice creation. Also, the government buyers of crops often imposed crop varietal requirements to standardize the production across different farmers, which drove farmers to adopt modern, improved varieties for their crop field production. As breeders became the dominant source for planting materials as a result, farmers started to use the same source to provide planting materials for home gardens despite the lack of similar pressures. The availability of such a source made farmers abandon their seed-saving practices, affecting the regional agrobiodiversity pool for home gardens.

3.4.2 The roles of the state in citrus adoption

While the autonomy of farmers was important in making field-relevant agrobiodiversity decisions, the Korean state also played an important role in creating favorable conditions for citrus adoption. In addition to those presented in Section 3.3.3., there were a few provisions the state offered uniquely. First, the state made trade-related provisions to facilitate citrus production and sale, including the Act, as mentioned in Section 3.3.3. Such provisions succeeded in protecting Jeju's citrus production when the industry was new and fragile. Additionally, credit was something only the state could feasibly provide to smallholders during that era (W. Kim 2019). This credit backed the smallholder-led agricultural expansion, as the lack of fund can be an important entry barrier (Vadez et al. 2004, Turner and Davidson-Hunt 2016). Although the state itself did not and could not make significant development incursions into the "wasteland" of Jeju forests and other natural areas, state loans enabled local farmers who had the drive and local knowledge to do so. Forest and other wild land clearings were especially important for poorer smallholders who otherwise had little spare land resources to devote to non-staple crops like citrus. State policies thus enabled Jeju farmers of a broader wealth spectrum to seize the high-return opportunity of citrus production.

3.4.3 Spatial compatibility between subsistence and commercial crops during agricultural commercialization

The contrast between farmers' receptions of Tongil-style rice varieties and their receptions of citrus confirms findings from previous studies (e.g., Basu 2009) that new adopted crops should fit into the existing systems of cropping and other livelihoods. The findings in Jeju particularly echo the need for spatial compatibility between the crop and the system. During agricultural transitions that include commercial crop adoption, marginal land (e.g., field margins and home gardens) can be used either as sites for the production of the new adopted crop, as seen in other smallholder-initiated adoptions of high-return crops (Steward 2013), or as sites for the continued cultivation of "rescued" agrobiodiversity that used to occupy other components of the land use system (Coomes and Ban 2004; Rerkasem et al. 2009). Adopting a crop that is of particularly high compatibility with the existing system may reduce the spatial pressure that the new crop exerts on the existing production system (Boulay, Tacconi, and Kanowski 2012; Turner and Davidson-Hunt 2016).

Further, it is important to recognize the conditions and limits of a "high-spatial compatibility crop." Compatibility varies depending on the nature of the crop (e.g., habitat requirements) and how cropping is practiced (e.g., planting density). For example, tree crops tend to be more spatially compatible with food (staple) crops that grow in the lower layers (Grossman 1993; Turner and Davidson-Hunt 2016). Fruit production typically generates significantly higher returns per unit area than staple production does. With good infrastructure, even small fruit stands may make significant contributions to the household economy without sacrificing too much staple-producing cropland. Citrus was especially a crop that did not need the highest-fertility lands in the land use system of Jeju, so the crop could be grown on former "wastelands." As the rocky wastelands of Jeju were never used for important subsistence crops like barley that needed better soil quality and added fertilizers, citrus did not significantly compete with subsistence crops in the earlier period of adoption. However, adopting a spatially less-demanding crop does not entirely prevent the loss of traditional agrobiodiversity. Even when traditional agrobiodiverse crops coexist with the new crops and crop varieties in a farming system, significant agrobiodiversity losses are undergone (Zimmerer 1996; Brookfield 2001; Brush 2004). Additionally, the social integrity that traditionally supports farmer-managed agrobiodiversity (e.g., social networks where seeds are exchanged) tends to decline as general commercialization prevails (Rerkasem et al. 2009; Howard 2010; Pautasso et al. 2013).

The case of citrus could help approach the production of some biofuel crops, like *Jatropha curcas* (jatropha hereinafter), that have been promoted as having high spatial compatibility because of their ability to be cultivated in "wastelands" (Ariza-Montobbio et al. 2010). Despite initial promises, crops like *jatropha* proved to underperform agronomically (Ariza-Montobbio et al. 2010; Baka 2014). Additionally, what the pro-*jatropha* adoption promoters regard as "wasteland" may actually be high-productivity land in the local land use system (Ariza-Montobbio et al. 2010; Baka 2014; Montefrio and Dressler 2016). The conversion of such lands into biofuel production lands in such cases may result in environmental, economic, and sociopolitical harm rather than help.

These reports show that a crop's compatibility with marginal lands is not an inherent trait of a crop as attempts to promote "wasteland crops" have implied. Such crops should not be prescribed or promoted without considering the local context. One reason why citrus adoption flourished in Jeju was that the local farmers already had knowledge of and experience with the "wasteland" that they developed into citrus stands. These farmers thus had a more keenly attuned sense of whether the land was truly replaceable and how any replacement would affect their livelihoods, compared with state promoters of crops or crop varieties. The autonomy given to Jeju farmers in these matters also allowed them to experiment with citrus and determine its true replaceability. From the state's perspective, it can only be known in retrospect whether a suspected wasteland is truly a wasteland.

3.5 Conclusion

This paper compared the adoption processes of improved crops and crop varieties in two regions of South Korea to highlight the effects of different state approaches to development. Rather than being invariably controlling or consistently flexible in all contexts, the state took different approaches in pursuing agrobiodiversity policies according to the crop and the region. Notably, crops that were more important to the nation's food security received more state attention. Rice received the heaviest and most forceful intervention in its agrobiodiversity, as the state was eager to increase its rice production. Additionally, some regions received more state development intervention than others. Jeju was allowed more autonomy, as the region had low agricultural productivity and was thus not expected to contribute much to the nation's food production growth goals. Nor were the region's unique forests and wild lands easy for the central government to understand, access, or use, neither were they expected to be high-productivity lands even if they were reclaimed and developed. State intervention in this region consequently remained relatively low, allowing farmers to choose their own paths. Perhaps ironically, they chose to proceed with development, but it was development on their own terms. The farmers were able to identify their own land to establish citrus stands and choose the pace at which they converted their subsistence land to citrus stands without significantly risking food security. Such autonomy was not afforded to rice farmers in high-productivity regions, because they, unlike Jeju farmers, had the burden of “feeding the nation.” The state, in this case, controlled individual farmers’ behavior and forced them to adopt state-bred high-yielding varieties of rice.

One reason for the success of citrus adoption in Jeju was the fact that citrus was a relatively high-spatial-compatibility crop that could be grown alongside the existing subsistence crop. It could be grown on converted wastelands and did not require the best of the farmland the household has. But the compatibility does not lie merely in the crop’s inherent traits. Rather, Jeju also had semi-agricultural lands (e.g., grasslands for fodder) that could be repurposed into citrus stands. Spatial compatibility, thus, is an interplay of the crop’s traits with its host locale’s biophysical environment and cultural land use practices in conjunction with the political–economic context. Furthermore, spatial compatibility is not a fixed score assigned to each crop but rather a dynamic value representing a process in which farmers experiment with cultivation of the crop to fit it into their existing livelihoods, which themselves undergo continuous change. The experimental approach was only possible in Jeju, because there was minimal top–down pressure from the state forcing a certain pace of citrus adoption.

Nevertheless, the South Korean state still played important supportive roles in farmer-initiated citrus adoption, including those regarding trade policies and credit, legal, and infrastructural provisions for the smallholders. This support helped smallholders who lacked resources to seize the high-income opportunity that commercial citrus offered. These roles of the state, however, are not exactly replicable in today’s contexts. Protectionist policies, like severe import restrictions, are impossible to implement in today’s liberal trade environment. Thus, the success story of citrus cannot serve as a blueprint for developing countries currently aiming at achieving food security and improved rural life quality. This paper’s results call for new ways to approach development in today’s context.

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Chapter 4

Useful plants from the wild to home gardens: Testing an ethnobotanical hypothesis in the changing land and livelihoods of Jeju province, South Korea

4.1 Introduction

Wild plants provide important benefits to local people, including food, medicine, and other goods and services (Bharucha and Pretty 2010; Christanell et al. 2010). In countries such as South Korea, the gathering of wild vegetables and other aromatic and medicinal plants for subsistence and income generation is popular even among urban people (Pemberton and Lee 1996; Lange 2004). Home gardens can contribute to conservation of wild plants, including indigenous forest species and crop wild relatives whose populations may be dwindling (Kumar and Nair 2004; Das and Das 2015). Such wild plant diversity in home gardens, along with the diversity of domesticated plants and animals in the gardens, can improve livelihoods (Powell et al. 2013) as well as help preserve associated local ethnobotanical knowledge (Benz et al. 1994; Gaoue et al. 2017). Nevertheless, research has been insufficient, especially in temperate regions, as to the internal and external factors that motivate the cultivation of useful wild plants in home gardens, including the specific utilities of the plants or availability within forests and other plant habitats nearby.

Transferring wild plants or planting materials from their original habitats to home gardens is a common practice by local people to ensure easy access to the plant products (Price and Ogle 2012; Kujawska et al. 2018). Forests and other natural and semi-natural areas can supply such planting materials, and having forest patches nearby can thus positively affect home garden plant diversity (Alcudia-Aguilar et al. 2017). However, these habitats can also serve as collection sites for wild plant products (Sunwar et al. 2006; Larios et al. 2013; Das and Das 2015), reducing the necessity for the plants' cultivation. Conversely, the scarcity of such nearby plant harvesting sites can prompt local people to cultivate useful wild plants in their own home gardens (Larios et al. 2013; Kujawska et al. 2018). Alarmingly, this scarcity has been increasing in rural locales, caused by forest loss (Johnson and Grivetti 2002; FAO and UNEP 2020), forest access restrictions (Benz et al. 2000; Barreau et al. 2016), habitat degradation due to increased human activities (Cole 2004), and livelihood and lifestyle changes that reduce human–nature interaction (Łuczaj et al. 2012).

Here, the author studied the cultivated plant diversity of 131 home gardens in 12 villages in Jeju Province, South Korea, especially focusing on useful wild plant taxa. This study posits that the Jeju home gardens are important sites and refugia for useful wild plant diversity as the region undergoes land, livelihood, and lifestyle changes that threaten the wild and semi-wild habitats of such plants and the local people's use of the habitats. To investigate the roles of the home gardens, this study examines how much of the locally used wild plants were cultivated in home gardens and what characteristics the cultivated plants had compared with those that were not grown in home gardens. The effect of proximal wild habitats, the source sites of such home garden planting materials, on wild plant diversity was statistically tested. Additionally, this study investigated the reported recent decrease in the availability of useful wild plants in Jeju, mainly from the late 1990s, and the land, livelihood, and lifestyle changes that have affected the availability and accessibility of these habitats to local people. Transfer of such plants from the wild to private spaces such as home gardens is hypothesized to be a management response by local plant users to such changes.

4.2 Methods

4.2.1 Study area

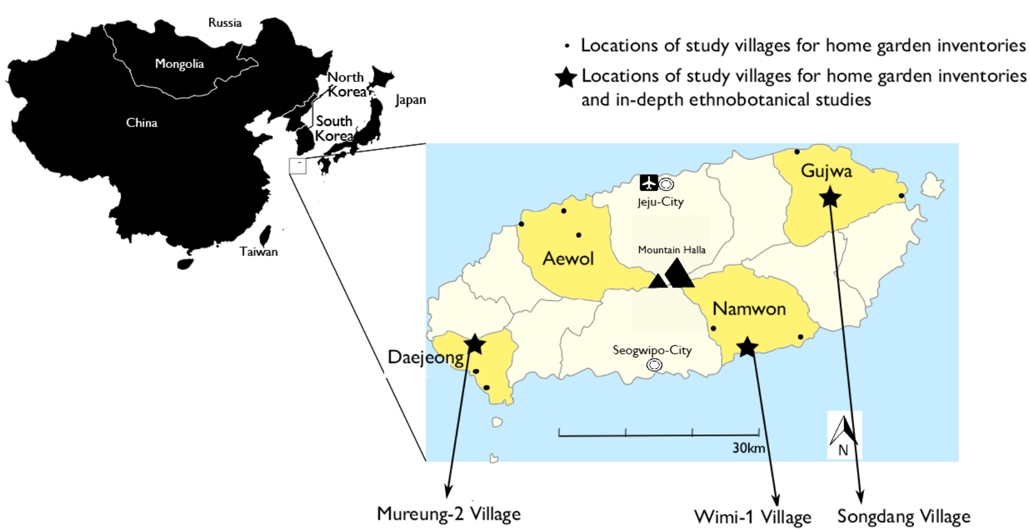


Image sources: (left) Zuanzuanfuwa (2009), (right) modified from Asfreeas (2011)

Figure 4.1: Map of study area (Jeju province) and locations of study villages

The study site, Jeju Island, with an area of 184,840 ha, is one of South Korea's seven administrative provinces (Figure 4.1). In 2015, the population was approximately 620,000, with 97% being ethnically Korean (Statistics Korea 2015). The island has a warm temperate climate with monthly average temperatures ranging from 6 to 27 °C and receives 1,500–1,800 mm of rainfall annually. The elevation of the island ranges from 0 to 1,950 m above sea level. As of 2015, most of the area was forest and other natural areas (47%; native evergreen forests and coniferous afforested areas), followed by agricultural fields (20%) and orchards (9%) in (Korean Ministry of Land Infrastructure and Transport 2015). Most settlements and developed areas are located within 200 m of coastal areas. The island's mountainous upland area is designated as a national park (Hallasan National Park; 15,310 ha) and also as a UNESCO biosphere reserve (Jeju Island Biosphere Reserve; 83,094 ha) for its unique and diverse flora and fauna.

Study gardens (*n* = 131) were sampled from 12 villages belonging to four sub-regions out of the ten rural sub-regions of Jeju (Figure 4.1). The four sub-regions (yellow-shaded areas in Figure 4.1) were selected to represent within-Jeju variations in biophysical traits that have been traditionally recognized (east–west variations in location affect soil properties and north-south variations affect climate). Three villages (one mid-hill, two coastal) were picked for each sub-region to represent differences within Jeju villages in altitude and the level of development.

4.2.2 Data collection and analysis

The fieldwork was done in two parts: one in 2015 and the other in 2016. The 2015 study inventoried all cultivated plants in 131 home gardens of Jeju and interviewed the garden tenders. All cultivated plants were recorded by the folk names given by garden tenders following previous research (Ban and Coomes 2004; Perrault-Archambault and Coomes 2008; Riu-Bosoms, Calvet-Mir, and Reyes-García 2014). For identification accuracy, the study consulted a list of local landraces surveyed in 2012 (Korea Women Peasant Association 2013) and a list of locally used plants compiled in 2011 (Kim, Jeong, and Kang 2015). Plants were primarily identified and analyzed at the species level, and high infraspecific variations such as those in *Brassica oleracea* were recognized as different taxa. Each plant taxon was classified as naturalized (gwihwa: plants that have non-native origins and have been accidentally or deliberately moved to the Korean environment), native or naturally occurring (jasaeng; plants of indigenous origin that have naturally occurred in Korea without human protection for a long time), or cultivated (jaebae; plants that have exotic or indigenous origins and have been bred by humans or whose regeneration has otherwise been managed to serve human needs) categories according to the

Korea Plant Name Index (KPNI) (Korea National Arboretum 2017a). This paper refers to plant taxa belonging to KPNI naturalized, native, and cultivated categories as introduced, wild, and domesticated plants, respectively, to reduce confusion (e.g., *Vigna angularis* is categorized in KPNI as a "cultivated" taxon but is also native to Korea). The garden tenders were also asked about uses, origins, and management of the plants they cultivate. All communications and notes were made in Korean.

The second part of the fieldwork in the winter of 2016 made a more in-depth examination of wild plant use and management. Three focus villages (Songdang, Mureung-2, and Wimi-1) were selected from the 12 villages (Figure 4.1), representing different Jeju sub-regions and elevations. These focus villages had different elevations and compositions of forest and non-forest lands in 1972 (c.f., Table 4.3) and adopted different specialized cash crops, and tourism differed in importance to the inhabitants' livelihoods (Table 4.1). Across the three focus villages, six home garden tenders (two for each village) were selected as key informants who were native to Jeju and had expert ethnobotanical knowledge. The interviewees provided details on the use of wild plants and plant management in the home gardens and elsewhere. They were also asked about availability changes, if any, of the plants they used. Further anecdotes on wild plant use and management in Jeju were acquired from published online sources (e.g., blogs, TV documentaries) to complement the results of in-depth interviews.

Table 4.1: Characteristics of three focus villages for in-depth studies

Village	Sub-region	Area (ha)	Population (2015)	Elevation	Main livelihoods
Mureung-2	Daejeong	611	562	Mid-hill (~200m)	Agriculture (e.g., garlic, citrus)
Songdang	Gujwa	3904	996	Mid-hill (~400m)	Agriculture (e.g., soy), tourism, animal farming
Wimi-1	Namwon	1363	1751	Coastal	Agriculture (citrus)

Data source: Research Institute for Regional Government and Economy of Korea (2015)

The characteristics of cultivated plants in the 131 home gardens were analyzed in comparison with all useful plants recorded in the region to examine the role of the gardens in conserving the plants. The list of plants acquired from the 2015 fieldwork was compared with a list of ethnobotanical plants in Jeju compiled in 2011 that yielded 356 plant taxa (312 species, 2 subspecies, 37 varieties, and 5 formae) from 177 informants (Kim, Jeong, and Kang 2015; Kim, Jeong, and Kang's list hereinafter). The 356 taxa included 16 introduced and 86 domesticated plant taxa according to KPNI system, in addition to 254 KPNI-native (wild) plants. Ethnobotanical plants were defined as native plants traditionally used according to local knowledge. The informants were requested to list names and uses of all ethnobotanical plants they knew. The native plants according to these sources denoted plants of indigenous origin or plants of exotic origin that have been naturalized long time ago to have developed folk uses and therefore did not perfectly correspond to the native (or naturally occurring) plants in the KPNI classification. Among the 356 ethnobotanical plants, those cultivated in home gardens were compared with those not cultivated in home gardens to examine the home garden-inclusion criteria of those plants. Plant uses were derived from Kim, Jeong, and Kang's list to allow unbiased comparison. This study posits that home garden tenders tended to cultivate plants of certain characteristics such as compact size (e.g., herbaceous plants) or higher use value.

Section 4.3.2 investigates the connection between home garden plant diversity and land cover composition of the village to which the home garden belongs. A greater proportion of natural and semi-natural land cover nearby is hypothesized to positively affect the wild plant diversity in home gardens, as these land types are source sites of planting materials for home gardens. Alpha and gamma diversities of home garden-cultivated plants were compared between 12 study villages and 4 sub-regions to detect arising geographic patterns. Outlier home gardens that harbored more than 750 plant individuals (n = 8) were not included in this section's analyses. As the villages had unevenly sized home garden samples (n = 9–14), the sample size for the alpha and gamma diversities was set to n = 10 per village (with an exception of one village that had n = 9) to prevent overestimation of gamma diversity in villages and sub-regions with larger sample sizes. Excess samples were excluded randomly. A linear regression was then performed with home garden plant diversity values (plant taxa richness divided by domestication status) as dependent variables and the proportion of natural and semi-natural land covers (forest and grassland), agricultural land covers (dry field, paddy field, orchard), and other land covers as independent variables.

Section 4.3.3 analyzes land use and land cover changes to examine potential changes to the composition and configuration of wild habitats of useful plants that are accessible to people. To overview changes in the entire Jeju province, a land cover map (late 1990s) and a land cover changes map (late 1990s–late 2000s) were used (Figure 4.6). The latter period was the period in which key informants perceived a noticeable decline in useful wild plant availability in the natural and semi-natural areas. For the three focus villages, land cover changes over a broader time frame (1972–2016) were analyzed at a finer scale. The analysis used topographical maps (national base maps) of Jeju at 1:25,000 scales that encompassed the village settlements and the surrounding areas (Figure 4.7). The maps are produced by the government and depict topography (contour lines), landmarks, and some land uses (e.g., forest, agricultural land uses). The time period of 1972–2016 was selected, as the 1970s and the 1980s were the periods with the most active cropland expansion according to preliminary interviews. The period of the 1990s–2016 experienced continued cropland expansion and changes to specialized crops in some regions, as well as other livelihood changes. The maps were based on aerial photographs and were ground-truthed around the time of map creation via government surveys (National Institute of Geography). The maps were drawn from archives and no detailed information is available regarding the sources of the photographs or the ground-truthing method.

4.3 Results

4.3.1 Characteristics of tenders of home gardens and useful plants in home gardens in relation to all useful plants in Jeju

Demographically, Jeju natives comprised 87.5% of the tenders of sampled home gardens. The respondents' average number of years of residence was 47.6, and more than 70% had lived in the house for 25 or more years. The number of family members varied from 1 to 10, averaging 2.67 persons per household. Of the 129 respondents, the average age of the garden tender was 68 (ranging from 20 to 94). Seventy-five (58.1%) gardens were managed by a sole female garden tender, 33 (25.6%) by a sole male garden tender, and 21 (16.3%) by both female and male garden tenders. In terms of livelihoods, 89 (70.1%) of the sampled households were engaged in farming, and two-thirds of the currently farming households were farming full time. There was no statistically significant difference in demographical characteristics (age, gender, farming status) among the sampled garden tenders between those who did and did not cultivate wild plants in their home gardens. However, the cultivators of wild plants had higher proportion of those who were actively managing their farms (73% vs. 64%).

Compared with the population in rural Jeju (Statistics Korea 2015c), the following characteristics were observed in the sample. The female ratio in the sample was higher than the 5:5 ratio in the population, indicating that women are more highly involved than men in home garden plant cultivation. Additionally, the sample had a larger number of long-time (25+ years) residents (70.2%) than the general rural population (35.5%) did. Similarly, over 87% of the sample households (n = 111) had farming experience and over 70% (n = 89) were engaged in farming. In the population, the farming households were a minority (30%). Such differences indicate that the female, long-time residents and farming populations in rural Jeju are more likely to cultivate home garden plants than others.

The sampled home gardens (n = 131) from the 12 study villages of Jeju had a total of 164 taxa of cultivated plants, corresponding to 125 genera and 64 families. The 164 taxa corresponded to 153 unique species and five additional species whose ten cultivars and one forma were recognized as different taxa (e.g., cultivars broccoli, kale, and cabbage of the species *Brassica oleracea*). Of the 164 taxa, 100 (61%) were herbaceous plants (annual, biennial, and perennial), and the rest were woody plants (woody vines, shrubs, and trees). The average garden had 10.7 cultivated plant taxa. Of the total cultivated plant taxa, 53 (32.3%) were wild taxa that were native to Korea ("wild plant" hereafter), whereas 108 (65.9%) were domesticated taxa and 3 (1.8%) were introduced ones. Of 131 home gardens, 91 (69.5%) had at least one wild plant. Among the 91 gardens, the average numbers of wild plant taxa and individuals were 2.68 and 27.13.

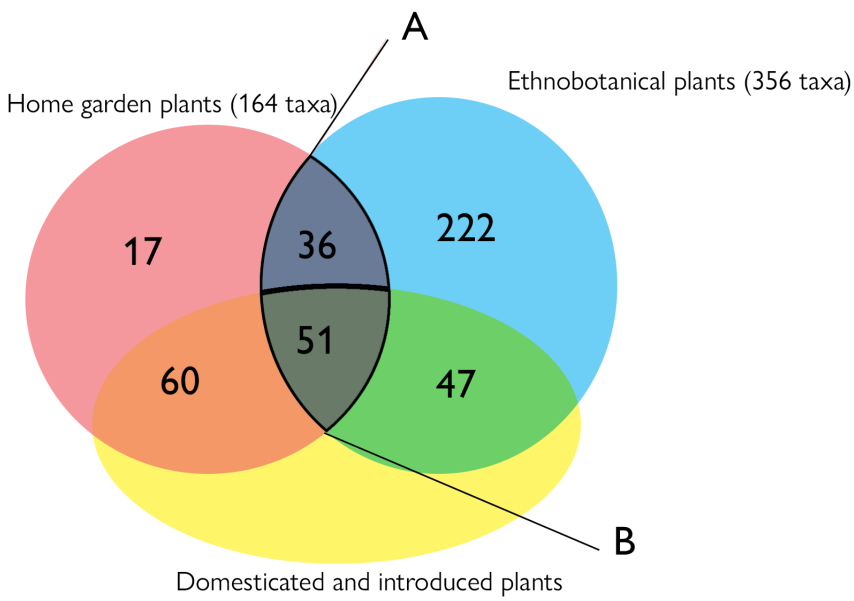


Figure 4.2: Venn diagram of home garden-cultivated plant taxa and all ethnobotanical (useful) plant taxa of Jeju

A total of 87 taxa (86 species and two cultivars of *Perilla frustescens*) occurred in the in this study's plant inventories of home gardens and Kim, Jeong, and Kang's 2015 ethnobotanical plant list: 36 wild taxa, 50 domesticated taxa, and 1 introduced taxa (see Figure 4.2 A and B). The wild taxa were native to Korea, and the domesticated taxa included both native and non-native taxa that have traditionally been cultivated in Korea (e.g., carrots). The 87 overlapping taxa made up 53% of the home garden plants and 24.4% of the ethnobotanical plants. The 36 overlapping wild taxa made up 67.9% of all wild species in home gardens and 13.9% of all wild species in the ethnobotanical plant list. Among 17 of the 53 wild plant taxa in home gardens that were not listed on the ethnobotanical plant list, 15 were on another list of ethnobotanical plants in Jeju (Korea

National Arboretum 2017b). In sum, most wild plants in home gardens were associated with local ethnobotanical knowledge, while only a moderate portion of ethnobotanical plants occurred in home gardens.

Most of the 87 home garden plants were used for food and medicinal purposes. Of all the taxa, 63 could be used for food, and 82 had health and medicinal properties. Wild and domesticated plants had similar proportions of uses, although a larger portion of wild plants had edible and medicinal uses (Figure 4.3). Ritual uses (e.g., food offerings for ancestral rites) were more common among domesticated plants. Table 4.2 shows the list of wild plant taxa that most frequently occurred in the studied home gardens and their uses.

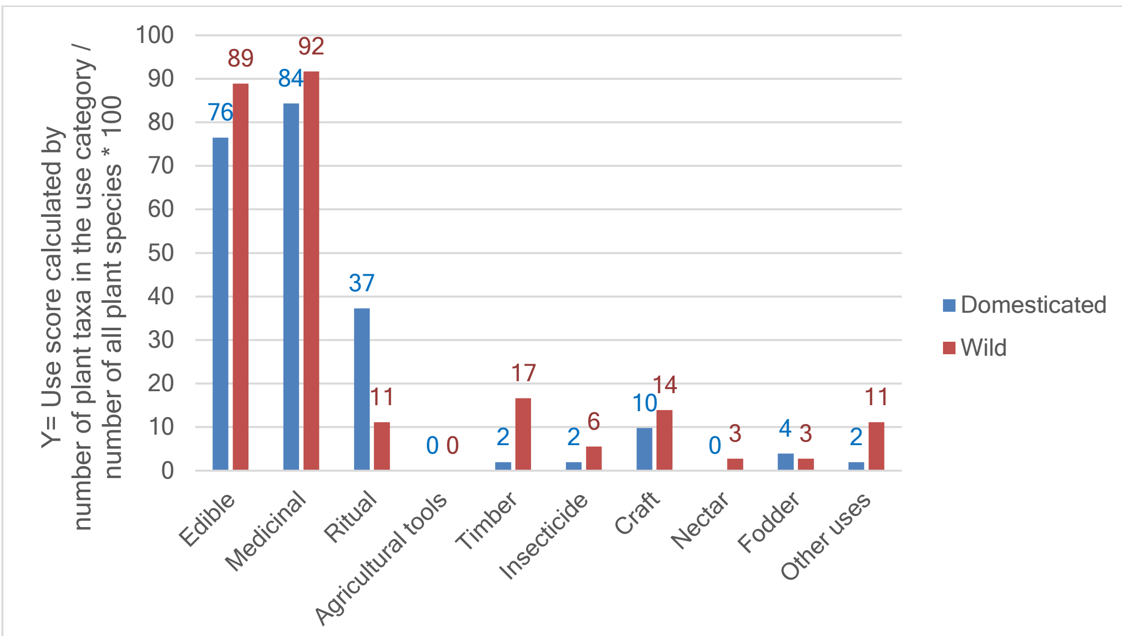


Figure 4.3: Proportion of plant uses by the plant's domestication status in home gardens

Ethnobotanical plants in home gardens were typically more versatile in the plants' uses than those that did not occur in home gardens. The ethnobotanical plants in home gardens (87 taxa) in general had an average of 2.13 uses per plant taxon, whereas those that did not occur in home gardens (269 taxa) had 1.47 uses. Among the home garden-cultivated ethnobotanical plants, wild plants had a higher number of average uses per taxa (2.39 uses) than domesticated plants (1.96 uses). Wild plants that did not occur in home gardens (222 taxa) had 1.44 uses, indicating that they were less versatile than wild plants in home gardens.

Table 4.2: List of 30 wild plant taxa that most frequently occurred in home gardens and their uses

No.	Scientific name	No. of home gardens	No. of total plant individuals	Ed	Me	Ri	Ag	Ti	In	Cr	Ne	Fo	Ot
1	*Diospyros kaki*	65	118	1	1					1			
2	*Camellia japonica*	24	100	1	1			1					1
3	*Peucedanum japonicum*	16	186	1	1								
4	*Zanthoxylum piperitum*	16	20	1	1								1
5	*Platycodon grandiflorum*	12	274		1								
6	*Codonopsis lanceolata*	11	309	1	1								
7	*Oenanthe javanica*	11	280	1	1	1							
8	*Polygonatum odoratum* var. *pluriflorum*	9	65	1	1								
9	*Aralia elata*	5	5	1	1								
10	*Farfugium japonicum*[1]	5	18										1
11	*Aster scaber*	4	60	1	1								
12	*Elaeagnus umbellata*	3	3	1	1					1			1
13	*Taraxacum platycarpum*	3	37	1	1								
14	*Ligularia fischeri*	3	41	1	1								
15	*Kalopanax septemlobus*	3	3	1	1					1			
16	*Plantago asiatica*	2	310	1	1								
17	*Brassica napus*	2	70	1						1	1		
18	*Lonicera japonica*	2	52	1	1	1							
19	*Sedum sarmentosum*	2	90		1								
20	*Pimpinella brachycarpa*	2	21	1									
21	*Ulmus davidiana*	2	11	1	1			1					1
22	*Acer palmatum*	2	2		1								
23	*Vitis coignetiae*	2	2	1	1					1			
24	*Celtis sinensis*	2	2	1	1			1					
25	*Ilex rotunda*[1]	2	4					1					
26	*Neolitsea aciculata*[1]	2	24				1						1
27	*Agastache rugosa*[1]	2	14	1									
28	*Salvia plebeia*[1]	2	8	1	1								
29	*Polygonatum odoratum* var. *pluriflorum* f. *variegatum*[1]	2	7										1
30	*Daphne kiusiana*[1]	2	2										1

Acronyms of plant use: Ed: edible, Me: medicinal, Ri: ritual, Ag: agricultural tools, Ti: timber, In: insecticide, Cr: craft, Ne: nectar sources, Fo: fodder, Ot: other uses

[1] Marked taxa were not listed in Kim, Jeong, and Kang's list. The uses for the taxa were derived from author's fieldwork and another source of Jeju ethnobotany (Korea National Arboretum 2017b)

Ethnobotanical plants present in home gardens were most commonly used as food or medicine compared with those managed elsewhere (Figure 4.4). Food uses were twice as common among home garden-occurring plants (57 of 87 [65.5%] home garden taxa) as food plants absent in home gardens (88 of 269 [32.7%] taxa). The home garden plants also more commonly had medicinal uses (87.4% versus 75.8%) as well as ritual and craft uses. Ornamental uses, although not in the ten use categories, were another strong use category among home garden plants according to interviews.

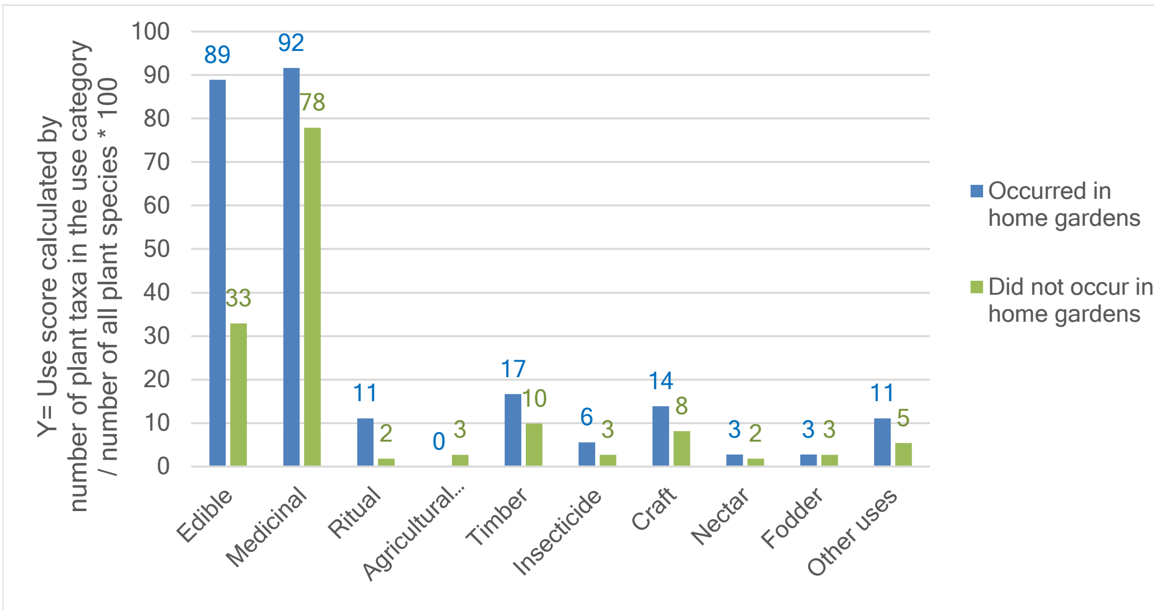


Figure 4.4: Proportion of uses for useful plants that did and did not occur in home gardens

Among all ethnobotanical plants, the proportion of woody plants did not significantly differ between plants cultivated in home gardens and those not cultivated in home gardens. Among the 87 home garden-cultivated taxa, 34 were woody (39.1%). Of the 269 non-cultivated taxa, 103 (38.3%) were woody. The woody plant proportion was also consistent among all ethnobotanical plants (136 of 356 taxa, 38%) and home garden plants (64 of 164 taxa, 39%), indicating that home gardens conserve useful woody plants as much as they do useful herbaceous plants in terms of taxa richness. However, the woody plants constituted only 1.9% of all plant individuals in home gardens, indicating that their home garden populations did not form a vast genetic pool of agrobiodiversity.

Garden tenders typically did not make use of the full range of plants known to the region. Many of the edible plants had been eaten in the past but were not people's preferred choice (e.g., barks of *Ulmus davidiana*) after economic betterment. Camellia (*Camellia japonica*) traditionally had food, medicinal, fence (barrier), ornamental, and cosmetic uses, among which only fence and ornamental uses were being practiced in 2015. Additionally, home garden tending was the domain of older people (average age of garden tenders of the 131 study gardens was 68). Younger members of the households, typically engaged in non-farm livelihoods, often did not know the names or uses of the plants in the household's garden. Many garden tenders also had inherited the garden along with the house from their parents. Many such tenders did not know or use the plants they inherited.

4.3.2 Source of wild plants in Jeju home gardens: Interview results and statistical relationship with natural and semi-natural land cover nearby

Wild plants in home gardens mostly originated from wild and semi-wild habitats (e.g., forests, crop field margins) according to self-reports from the six in-depth interviewees. The two Mureung interviewees stated that taking planting materials from the local forest was a common activity among the villagers. Among 59 home garden tenders, 36 (61%) sourced wild plants from non-human sources (e.g., direct transplanting, taking cuttings from local forests). In contrast, 75 (87%) of 86 tenders sourced domesticated plants from human sources (e.g., sellers in market). Acquisition of the planting materials mainly happened during livelihood activities (e.g., farmland management) or recreational activities (e.g., hiking), or the tenders made intentional trips to known source sites (e.g., local hills) to obtain the materials. Professional sellers also sold seeds and young plants of wild taxa (e.g., *Hovenia dulcis*) in the local periodic markets. The sources of the planting materials were tracked back to wholesale breeders that have Jeju-wide and sometimes nationwide networks. However, the garden tenders reportedly did not rely on such sources except for highly common and commercialized wild plants (e.g., *Platycodon grandiflorum*). Wild plant acquisition from wild and semi-wild sources contrasted with that of domesticated plants in home gardens from professional sources.

A village-level analysis found a statistical correlation between plants in home gardens and wild and semi-wild habitats nearby. Table 4.3 shows the basic statistics of the 12 study villages as well as the composition of the villages' land cover and plant diversity statistics of the home gardens in the villages (as of 2015). The richness of wild plant taxa found in the home gardens (gamma diversity) was the highest in the upland village of each sub-region (typically most mountainous). Table 4.4 and Figure 4.5 show the results of the linear regression analyses between the villages' areal proportion under different land use and land cover types and the plant diversity of the villages' home gardens (alpha diversity). The results reveal that the wild plant taxa richness (y) shows a significant positive correlation with the percent area of forest and grassland (x) in the village. In contrast, the same y has negative correlations with percent area of agricultural land cover. The results corroborate the interview findings that wild plants were sourced from wild and semi-wild habitats in nearby forests and grasslands. However, domesticated plant taxa richness had negative correlations with percent area of other land cover (e.g., roads, residential areas). Villages with larger proportions of other land cover were more developed villages with higher population densities and better access to industrial infrastructure such as large supermarkets. Considering most domesticated plants in Jeju home gardens were sourced from human sources (e.g., professional sellers), the close proximity of the villages' gardens to the source locations (e.g., markets) could be expected to positively affect plant diversity. This was not the case in this chapter's analysis. Instead, there was a negative relationship between other land cover and domesticated plant diversity. The negative relationship could be explained by the developed villages' other characteristics that are not related to proximity to planting material sources that may hinder cultivation of diverse plants in home gardens. For example, the developed villages tended to have smaller interhousehold spaces, which limited space that could be used as home gardens.

In addition to differences in composition of wild and semi-wild areas, the distance between a human settlement and the nearest forest was different by village and affected the local people's plant collection and use. In Mureung, where the forest patches were closer to settlements, local people visited the forests to obtain useful plants, whereas in Songdang (farther from the nearest forest), plant users typically collected useful plants when visiting distant sites such as farms or higher mountains. It was also important for plant collection and use that the livelihoods of plant users brought them to use broader land that may harbor useful plant habitats. For example, farms typically bordered upon natural and semi-natural areas) and farmers who frequently visit such land could have greater contact with potential plant habitats in such areas. Farmers interviewed reported they used such habitats to find useful plants. It could be logically assumed that officeworkers or people on pension, in contrast, did not have the similar kind of contact with such habitats.

Table 4.3: Study village information, land use and land cover composition, and home garden plant diversity statistics

	Region	**Aewol (Northwest)**			**Gujwa (Northeast)**			**Daejeong (Southwest)**			**Namwon (Southeast)**		
	Village name	**Gwakji**	**Shineom**	**Yusuam**	**Gim-nyeong**	**Jongdal**	**Song-dang**	**Hamo-2**	**Ilgwa-2**	**Mureung-2**	**Wimi-1**	**Tae-heung-2**	**Harye-2**
Basic info [a]	Population	1257	1066	1252	2787	1281	996	2238	618	562	1847	1192	550
	Elevation	coastal	coastal	upland	coastal	coastal	upland	coastal	coastal	upland	coastal	coastal	upland
	Area (ha)[a]	415	543	1969	1995	1706	3904	361.5[b]	387.1[b]	1222.7[b]	2725[b]	763[b]	2556[b]
Land cover [a]	Paddy field (ha) (%)	0 (0.0)	0.5 (0.1)	0.8 (0.0)	0 (0.0)	30.3 (1.8)	0 (0.0)	0.3 (0.1)	1.5 (0.4)	6.8 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)
	Dry field (ha) (%)	272 (65.5)	281 (51.7)	199 (10.1)	456 (22.9)	464 (27.2)	554 (14.2)	182.4 (50.5)	216.4 (55.9)	614.1 (50.2)	161 (5.9)	141 (18.5)	108 (4.2)
	Orchard (ha) (%)	22 (5.3)	99 (18.2)	37 (1.9)	5.4 (0.3)	14.2 (0.8)	10.4 (0.3)	1.2 (0.3)	15.2 (3.9)	94.8 (7.8)	970 (35.6)	393 (51.5)	481 (18.8)
	Forest (ha) (%)	56 (13.5)	53 (9.8)	1155 (58.7)	1146 (57.4)	834.9 (48.9)	1252 (32.1)	38.9 (10.8)	51.8 (13.4)	321.1 (26.3)	1085 (39.8)	50 (0.7)	1792 (70.1)
	Grassland (ha) (%)	0 (0.0)	0 (0.0)	308 (15.6)	4.1 (0.2)	167.8 (9.8)	1658 (42.5)	0 (0.0)	0.8 (0.2)	0.6 (0.0)	101 (3.7)	0 (0.0)	0 (0.0)
	Other (ha) (%)	64.9 (15.6)	109.5 (20.2)	269.2 (13.7)	383.5 (19.2)	194.8 (11.4)	429.6 (11.0)	138.7 (38.4)	101.4 (26.2)	185.3 (15.2)	408 (15.0)	179 (23.5)	175 (6.8)
Home garden plant diversity	Number of gardens	10	10	10	10	10	10	10	9	10	10	10	10
	Total plant taxa	51	49	67	45	45	45	37	36	41	33	47	53
	Wild plant taxa	6	7	12	5	8	11	3	1	4	4	8	13
	Domesticated plant taxa	45	42	55	40	37	34	34	35	37	29	39	40

[a] *Data source*: Research Institute for Regional Government and Economy of Korea (2015)

[b] Area information for the villages was aggregated across villages of the same name but of different numbers (e.g., 361.5 ha is the area of all Hamo villages, including Hamo-1, Hamo-2, and Hamo-3), while home garden plant data was gathered from the specified village (Hamo-2 only).

Table 4.4: Correlation between village-level land cover composition (x, %) and the richness of home garden plant taxa by domestication status (y) (Both x and y data were collected in 2015)

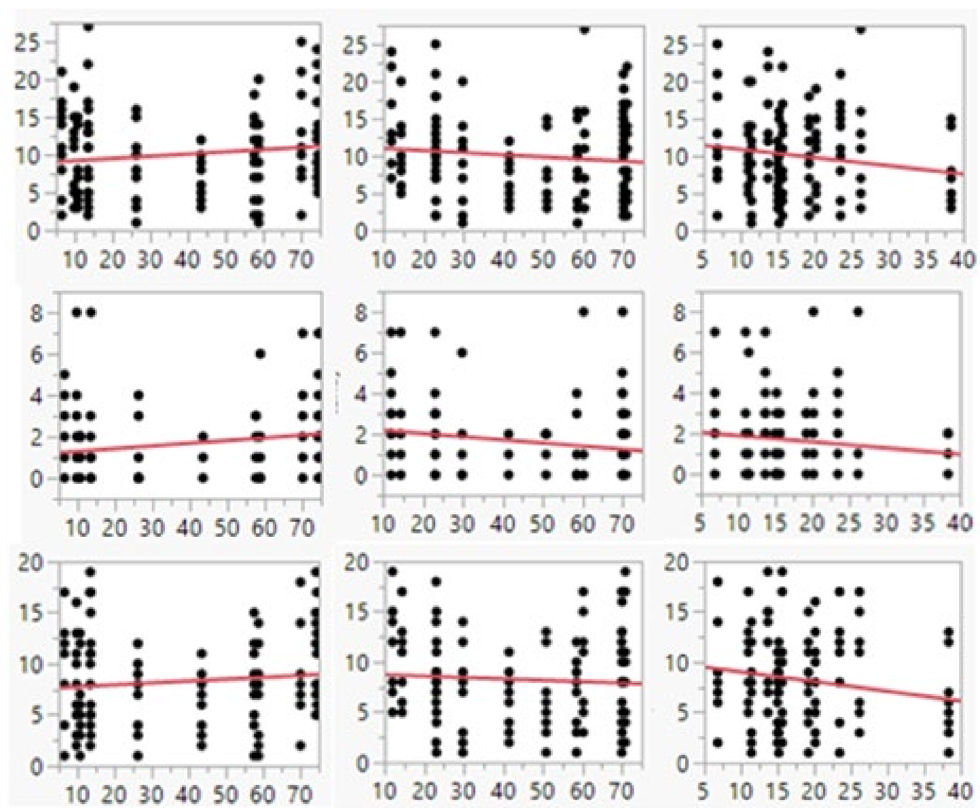
	% forest and grassland		**% agricultural land**		**% other land cover**	
	R^2 adjusted	**P**	**R^2 adjusted**	**P**	**R^2 adjusted**	**P**
Wild	0.032	0.025*	0.029	0.033*	0.014	0.104
Domesticated	0.004	0.228	-0.004	0.465	0.023	0.050*
Total	0.011	0.133	0.004	0.232	0.016	0.085

* Marked *P*-values were statistically significant (<0.05)

Total taxa

Wild plant taxa

Domesti -cated plant taxa



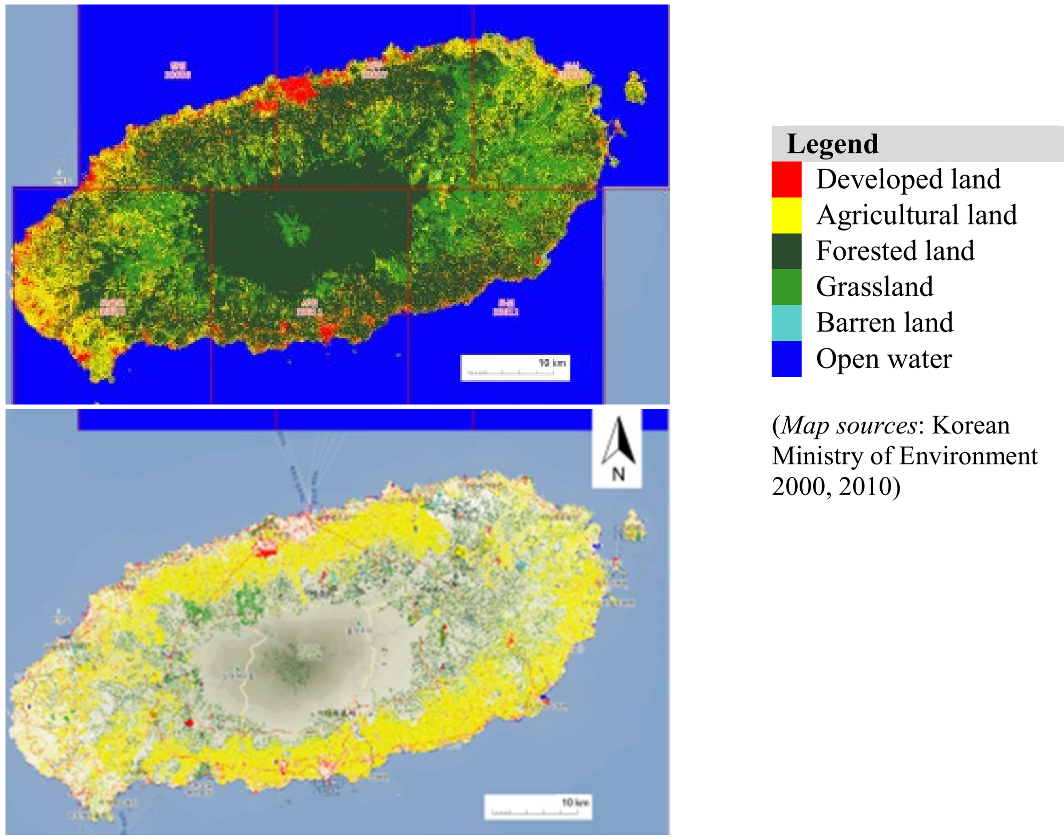
% Forest and grassland   % Agricultural land   % Other land cover

Figure 4.5: Linear relationships between village-level land cover composition (x, %) and home garden plant taxa richness by domestication status (y) (n=123 home gardens excluding outliers)

4.3.3 Land use and land cover changes in Jeju (1972–2016)

(a)

(b)



(*Map sources*: Korean Ministry of Environment 2000, 2010)

Figure 4.6: Maps of (a) land cover of Jeju in the late 1990s and (b) the land cover conversion between the late 1990s and late 2000s (specific years not specified by the source). Color overlaysin (b) (See legend for color coding by land use type) show areas where cover type changed during the period, and the colors denote the after-change land cover.

The region of Jeju experienced a large-scale land conversion from the onset of agricultural commercialization (1960-), while later tourism development also altered land cover of the province and its use. Forests and other natural and semi-natural land covers were extensively cleared for agricultural purposes as well as for roads, service areas, and other infrastructures related to tourism and general development of the region. Figure 4.6 shows the land cover of Jeju in the late 1990s (a) and the changes to the land cover between the late 1990s and the late 2000s (b), which includes the time period that local plant users cited as the period of most noticeable decline in plant availability. The most prominent change, represented by the yellow-colored areas in Figure 4.6 (b), is the conversion of non-agricultural lands into agricultural lands. The other developments mainly occurred along the coastal areas where settlements and important socioeconomic functions had been already concentrated. The higher-elevation forested areas in the middle of the island in Figure 4.6 (a) are protected as the Hallasan National Park and remain mostly undeveloped. Comparing Figure 4.6 (a) and (b) shows that the converted areas were largely forested land and grassland in the late 1990s. After the late 2000s, the main land use to which forest cover was lost shifted to, by order of importance, tourism infrastructures (e.g., golf course), road networks, residential areas, and croplands (Go 2012).

Land changes in the three focus villages between 1972–2016 show the results of cash crop adoption, other livelihood changes, and lifestyle modernization (Figure 4.7). In all three villages, adoption of specialized commercial crops such as citrus, commercial soy, and garlic ("orchards" and "dry fields" in the Figure 4.7 legend) led to replacement of forested land, other wild and semi-wild lands, and subsistence crop fields ("dry fields") to cash crop fields. Different types of changes occurred according to inter-village differences in initial land use and land cover setting as well as differences in newly introduced livelihoods (See Table 4.1 for the differences).

In Figure 4.7, maps of Mureung (1) and Wimi (2) show cropland-to-cropland replacements during the 1972–1997 period. In both villages, the mapped areas had already been densely covered by crop fields in 1972 ("dry fields"), but at the time, the fields were mostly planted with traditional subsistence crops (e.g., barley-foxtail millet rotation). Citrus stands ("orchards") in Wimi and garlic in Mureung replaced traditional crop fields. Citrus and grapes also became popular cash crops in Mureung after 1997. Fruit tree stands ("orchards") further filled the spaces between the existing crop fields in Mureung (Figure 4.7 [1]).

In addition to existing croplands, Jeju households cleared forests and other wild and semi-wild lands for the establishment of cash crop fields and to serve other needs arising from new livelihoods and lifestyles, resulting in loss and fragmentation of forest patches. In Mureung (Figure 4.7 [1]), the forest patches in the boxed area were lost due to establishment of new crop fields between 1972 and 2016, while in the oval demarcation, the large patch of forest was partly developed into agricultural processing facilities and recreational areas. In Wimi (Figure 4.7 [2]), forest patches were already relatively small in 1972, and the boxed areas A–C show further loss and fragmentation of the existing patches due to establishment of new fruit tree stands. In Songdang (Figure 4.7 [3]), more extensive forest loss occurred because of tourist resort development. In addition to forests, non-forested land was used for cash crop field establishment. In Figure 4.7 (3), in 1972, most of the mapped area was neither forested nor used as farmland. unlike the cases of other two villages where most land was forested or cropped. Upland villages like Songdang typically had a vast expanse of pasture for livestock due to the land's low fertility (Park and Jin 2019). Most Jeju households also traditionally managed grasslands for fodder and craft production that were later developed into croplands during the cash crop adoption period (Ko 2016).

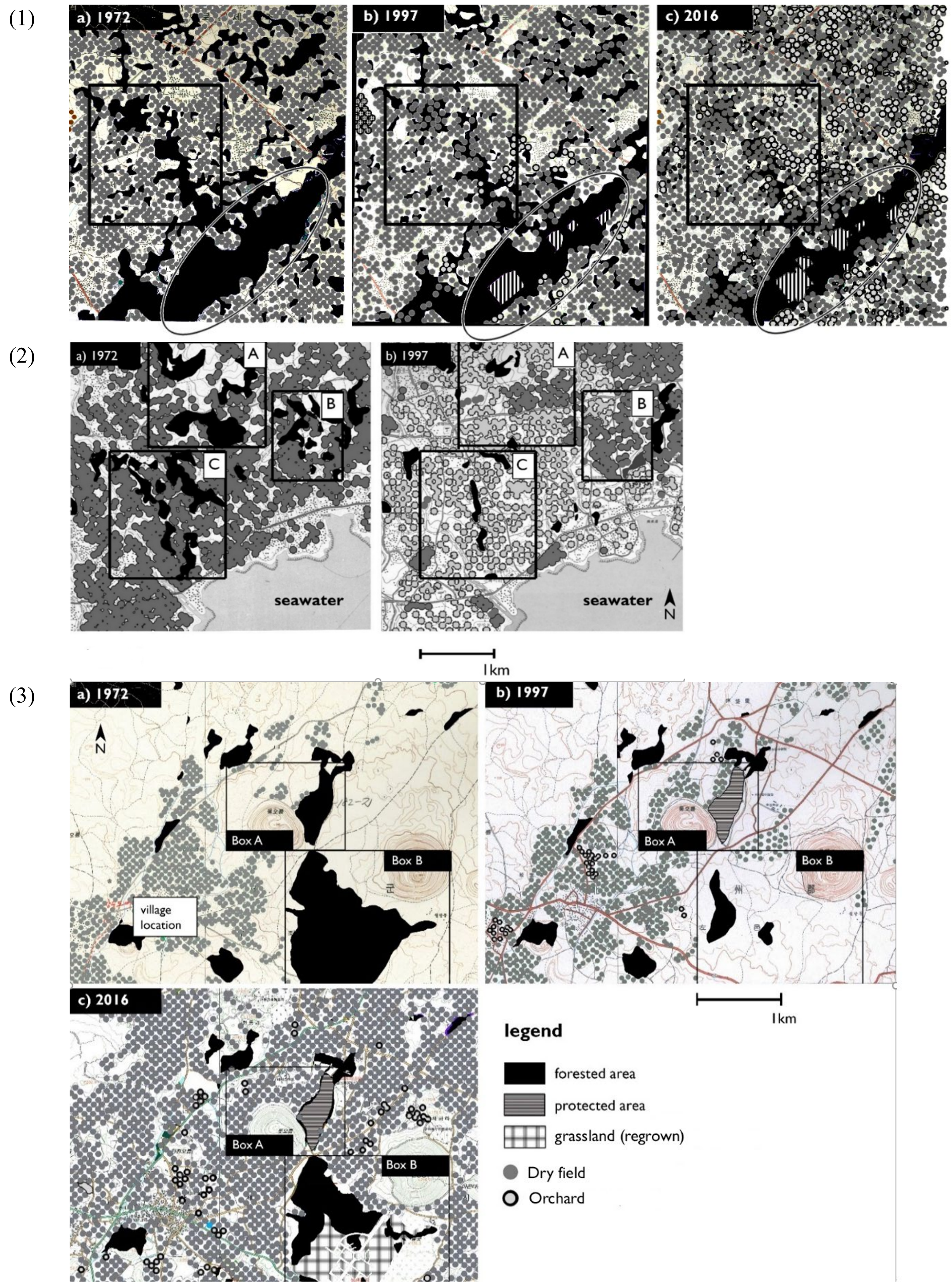


Figure 4.7: Land use and land cover in (1) Mooreung-2 village (Mureung hereinafter), (2) Wimi-1 village (Wimi), and (3) Songdang village (Songdang) in 1972, 1997, and 2016

Figure 4.7 (3) also shows the development of roads in Songdang between 1972 and 1996. The roads became a vital resource connecting the village to the market and other regions. The improved connection assisted livelihood transition and land changes that accompanied the transition, including cash crop-driven cropland expansion and development of tourist attractions.

4.3.4 Changes to plant availability and accessibility in relation to land use and land cover changes

All six participants in in-depth interviews reported a decrease in the availability of useful wild plants in their wild and semi-wild habitats since the 1970s. Additionally, two plant users reported a degradation in quality of useful wild plants. According to two Songdang interviewees, shortage became especially noticeable between 1996 and 2016. The plants in decline included food (wild vegetables and fruits), ornamental, and medicinal species. Some medicinally-used species became difficult to find (e.g., Korean dandelion *Taraxacum platycarpum*), while the quality of desired parts of those that could be found was degraded (e.g., the wild fruit *Akebia quinata* no longer produced quality fruits). Ornamental orchids of the genus *Calanthe* also became extremely rare.

The six plant users attributed the changes to two main drivers: deforestation and overharvesting of the plants in the collection area, with an emphasis on the latter. In addition, as source sites of useful plants, some local forested areas became inaccessible to local plant users. For example, some of the forests in the Songdang village area were designated as protected areas (e.g., a *Torreya nucifera* forest designated as a national monument in 1986; Figure 4.7 [3], Box A). Since the designation, the collection of plants from the area has been prohibited by law even to locals. This has reduced human–plant interactions essential for the acquisition of plants and the continuation of local ethnobotanical knowledge. Additionally, the local people nowadays mostly use motor vehicles to perform livelihood activities (e.g., commuting to farms and markets), reducing their everyday contact with potential plant habitats in general.

Overharvesting is reported to be a relatively recent phenomenon according to Songdang interviewees, attributed to increasing visitors to Jeju in the past few decades, ironically in the form that allows greater human-nature contacts among visitors. The protected area designation also has attracted tourists to the area, accompanied by land developments. For example, the tourist resort in Figure 4.7 (3) was constructed after the designation (early 1990s). Additionally, the establishment of "Olle" walking trails across various parts of Jeju attracted tourists, who hike along trails across local landscapes that include forests, agricultural fields, and human settlements. In addition to trails, hiking of oreums (small volcanic hills in Jeju) and other wild areas has become highly popular. However, the greater engagement with nature has increased the exposure of plant habitats to visitors, who may take useful plants from the landscape. This can be evidenced from the following: increasing number of social network posts (e.g., blogs) documenting collection and maintenance of rare Jeju-endemic plants that have ornamental value (Hyeon 2016a, 2016b), sharing tips on how to find large populations of wild vegetables in the wild (e.g., Cozy 2019), and organizing trips for wild food and medicinal plant harvesters (Korea Forest Service 2015). In addition to the relatively "casual" harvesters, Jeju's reputation for having a "clean nature" attracted professional commercial collectors of plants, by adding a premium to the island's medicinal plants' value on the market.

The resulting decrease in useful wild plant availability and accessibility played a role in the plant management decisions of the plant users, especially on whether to gather or cultivate. All six interviewees felt compelled to cultivate useful plants that were of value to them in their gardens because they were not sure if they could encounter the plants again soon. They were also aware of competition over rare or otherwise popular useful plants that could diminish the population of existing plants. The interviewees complained that they do not have much leisure time to make intentional trips for harvesting plants as some of the keen non-local harvesters do. However, the plant users preferred to collect more common or less popular plants from the wild. For example, popular wild vegetables *Artemisia princeps* or *Allium macrostemon* were abundant in the wild but rarely occurred in home gardens (EBS 2020).

4.4 Discussion

4.4.1 Role of home gardens in ethnobotanical conservation and factors affecting wild plant cultivation in home gardens

The findings of this study show that home gardens of Jeju harbor a significant array of useful plant taxa known to the region. The wild plants cultivated in these gardens are more versatile than those that do not occur in home gardens, making them a readily available source for essential needs (Finerman and Sackett 2003). The higher use versatility (higher number of local uses associated with the plant taxon) suggests that local people cultivate in their home gardens plants with which they have developed close relationships. Additionally, to be included in the garden, the plants have to appeal to the needs and desires of contemporary rural people, which typically include organic foods or the ornamental or recreational value of gardening in developed countries (Calvet-Mir, Gómez-Baggethun, and Reyes-García 2012, Zainuddin and Mercer 2014). In terms of taxa richness, the gardens host a significant proportion of woody plant diversity among all useful plants known to the region, although the sizes of the population were small. The results confirm that home gardens can contribute to the conservation of useful plants and the ethnobotanical knowledge formed around them, even when the region experiences economic growth and no longer critically depends on the plant products (Poot-Pool et al. 2015, Vogl-Lukasser and Vogl 2018).

4.4.2 Home garden plant diversity and the landscape matrix

This study's interview results also confirm that local people prefer to source cultivated or gathered plants from habitats more easily accessible to them (e.g., field margins) than from more distant locations (e.g., higher-mountain forests of Jeju) that may have greater plant diversity. The analysis of home garden tender demographics shows that the subset of people whose lifestyle allowed them to more frequently visit such easily-accessible habitats (e.g., farmers who visit their farms and the surrounding areas) were more likely to have wild plants in their home gardens. Those who cultivated wild plants in their home gardens had higher proportion of farmers among them than those who cultivated only domesticated and introduced plants. This could be explained by the fact that domesticated and introduced plants could be purchased from the local market, making it more accessible to a broader range of people who had diverse lifestyles. Wild plants, on the other hand, had to be mainly sourced from the original habitats, which explains why the plants were more likely to be found in the gardens of the people who more frequently visit such habitats. The result, thus, further supports the connection between the person's lifestyle and wild plant use, echoing the literature that having such habitats near homes or where livelihood activities occur facilitates greater ethnobotanical use of the sites (Powell, Hall, and Johns 2011).

Ironically, in Jeju, remote and less used forests in the higher mountains were well-protected, while a vast expanse of more accessible, lower-altitude forests were largely lost or fragmented during the study period (Figure 4.6, Figure 4.7). Designating forests and other natural habitats in less human-occupied areas as protected areas has been a popular solution for policymakers to avoid protests from local people who want to use or develop the areas near existing settlements and infrastructures (Jwa 2019). However, while the geographically differential designation may have reduced the net forest loss in Jeju to some extent, it also decreased the accessibility of forests to local people in general.

Reduced human–nature interaction could, in the short term, impel local people to respond to the loss by transferring the plants to private spaces such as home gardens for continued use

(Johnson and Grivetti 2002). When there is a lack of species-rich forests nearby, local users of useful plants tend to compensate by cultivating the plants in their gardens (Larios et al. 2013, Kujawska et al. 2018). If the trend continues, however, the local people might start to lose ethnobotanical knowledge and develop other compensation mechanisms. Especially in contexts where utilizing industrial substitutes is a viable option, people may purchase such substitutes instead of cultivating plants to fulfill the function (Belcher and Rui 2005). Jeju provides an example of this long-term effect over a few decades during which economic growth occurred.

The differentiation between short-term and long-term effects may explain the positive correlation found between forest and grassland covers in the surrounding lands and the home garden's wild plant diversity in Jeju, unlike some results of previous research (Larios et al. 2013, Kujawska et al. 2018). This indicates that having such wild and semi-wild lands nearby can help maintain ethnobotanical knowledge needed for the cultivation of the plants. Having such habitats nearby can give villagers' opportunity to engage with such wild and semi-wild habitats of useful plants to form or maintain local ethnobotanical knowledge, especially as livelihood and lifestyle changes are reducing the level of human–nature contact in the region. The explanation resonates with the results of previous research that found greater home garden plant diversity in a certain cultural landscape where people had a longer history of interacting with the landscape (Alcudia-Aguilar et al. 2017), thus forming greater knowledge.

4.4.3 Potential effects of tourism and protected areas on wild plant transfer to home gardens

The designation of a protected area, while one of the primary methods of biological conservation, can potentially lead to land development outside the protected area boundary (DeFries et al. 2007). Furthermore, an increase in the number of visitors in and around the protected areas may result in the overharvesting of useful plants. In Korea, especially after the 2000s, the culture of tourists shifted toward greater tourist engagement with the local culture and landscape (Jeon 2010), in keeping with the global trend of "wellness tourism" (Smith and Puczkó 2008), as evidenced by Olle walking trails suggested in Section 4.3.4. The change in local transportation toward greater automobile use has been pointed out as a reason for the diminished everyday contact of local people with nature, causing a decline in local ethnobotanical knowledge (Łuczaj et al. 2012). Combined with the greater engagement with nature among visitors, the diminished contact by local people with nature could create a disadvantage for the locals in the competition with visitors over useful plant collection. The sense of competition that the locals themselves feel was one of the reasons that compel the local people to change the management of useful plants, including the transfer of useful plants to their home gardens or other privately managed lands.

4.5 Conclusion

This is the first recorded study in Jeju and in Korea to investigate useful wild plants cultivated non-commercially. A geographical–ethnobotanical hypothesis that posits that plant users respond to the lack of forest and other natural and semi-natural sources of useful plants by transferring useful plants to home gardens was assessed. The approach combined an ethnographical method (in-depth ethnobotanical interviews), quantitative surveys (home garden plant inventories), and map analysis to connect the home garden plant cultivation practice to other sites of useful plant collection and management in the surrounding land.

The findings confirm previous research that home gardens contribute to the conservation of useful plant diversity of the region. A significant percentage of plant taxa previously recorded as useful in the region occurred in the study home gardens, and the plants were more versatile (mostly food and medicinal uses) than non-cultivated plants. However, the home gardens' contribution to infraspecific diversity was limited because the gardens were small, as were population sizes of the useful plants in the gardens.

Secondly, this study found that the proportion of forest and grassland cover in the surrounding land was positively related to the diversity of wild plants that occurred in home gardens. Greater natural and semi-natural covers nearby served as source sites for home garden planting materials. Moreover, the areas gave local people more opportunities to engage and develop relationships with useful plants to form local ethnobotanical knowledge. Differing from findings of some previous studies, the results show that home garden plant diversity is influenced by the cultural relationship the people have developed with the natural and semi-natural areas as well as absolute economic needs for the plant products.

Lastly, the land use and land cover analyses show various changes to the land that have affected the local people's use of forests and depleted the useful plant populations. The reduced accessibility and perceived population decline can prompt a compensation response from the people. One such response was a transfer of useful plants from the wild to home gardens to secure the plant's supply, which can have implications for the conservation of the plants' population and associated local ethnobotanical knowledge.

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Chapter 5

Conclusion: What now for home gardens and agrobiodiversity?

5.1 Major findings of this dissertation

This section opens the concluding chapter by summarizing the major findings of each of the empirical chapters (Chapters 2–4) and the overall findings of the dissertation.

Chapter 2 (Cultivated plant diversity in home gardens of Jeju, South Korea, and its determinants amid pronounced livelihood diversification) served as a base chapter, assessing the composition and diversity of Jeju home gardens based on a survey of 131 households in 2015. Additionally, the chapter investigated the geographic, livelihood, and demographic determinants of their diversity and composition. The home gardens of Jeju were typically quite small (approximately 0.03 ha on average) and single-layered in vertical vegetation structure, and the plant taxa richness was more modest (9.95 per garden) than in previously studied regions around the world (e.g., Ban and Coomes 2004; Clarke et al. 2014). However, the home garden was still an important site of agrobiodiversity in the agricultural system and the wider landscape of Jeju (See Chapter 4 summary later in this section for the home garden-landscape connection). The garden contributed the most to the agrobiodiversity that the farm household manages (81% of all cultivated taxa on average), supplying diverse foods, especially vegetables. This research expected that agrobiodiversity from the household's crop fields might have been incorporated into the home garden (as found in Ban and Coomes 2004), enriching the home garden agrobiodiversity, when Jeju's field agriculture transitioned from traditional high-agrobiodiversity agriculture to commercialized monoculture (approximately 1960–1980). This in fact happened modestly in the case of legumes, but rarely for other food groups. Instead, agricultural commercialization negatively affected home garden infraspecific diversity, leading to the delegation of planting material management from farmers to professional breeders, which negatively affected the infraspecific agrobiodiversity of the home garden and crop fields alike.

Chapter 2 also found conditions for greater agrobiodiversity in the home gardens of Jeju. Geographically, higher-elevation home gardens (approximately 200–400m above sea level, "mid-hill" villages) held higher plant diversity, being more isolated from food markets and having greater needs for subsistence foods. Agrarian traits generally positively affected home garden plant cultivation practice. Among the rural residents studied, farmers, older people (68 years on average), females, and Jeju natives were more likely to cultivate plants in their home gardens amid the de-agrarianization of livelihoods and lifestyles. The finding echoes the works of geographers who found female gender, indigenous cultural identity, older-age led to higher home garden agrobiodiversity in their study sites (Oakley and Momsen 2005; Perreault 2005; Perrault-Archambault and Coomes 2008). The positive correlation between the geographical isolation of the community and the home garden agrobiodiversity, however, contrasts with the result of Perrault-Archambault and Coomes (2008) who found a negative correlation between the two. The contrasting results can be explained by the difference in the role of informal planting material exchange networks in Jeju and in the Peruvian Amazon: As Jeju garden tenders sourced the planting materials for their gardens from professional sources instead of other garden tenders, the geographical isolation from other communities thus did not significantly affect the household's successful procurement of the materials. At the same time, among farm households, those with diversified household livelihood endeavors and with higher field crop diversity had higher home garden plant diversity, suggesting that field agriculture and diversified livelihoods do not significantly compete with home garden plant cultivation over household resources (e.g., labor) in the study region. The importance of field agriculture in fostering positive conditions for home garden agrobiodiversity resonates with findings of a non-geographic work of Reyes-García et al. (2012).

The home gardens' roles went beyond subsistence, being adaptable to the commercial needs of the household. The investigation of home gardens during the improved crop adoption period reported in Chapter 3 (Regionally divergent roles of the South Korean state in adopting improved crop varieties and commercializing agriculture (1960–1980): A case study of areas in Jeju and Jeollanamdo) showed that Jeju home gardens served as both commercial crop and subsistence production sites, affording smallholders entrepreneurial income opportunities in land-scarce situations during a period of active land development. The success of commercial citrus was not simply a result of the strong will of the farmers or because of the citrus tree's technical trait of growing relatively well in marginal land. Employing a political ecology approach, the chapter comparatively analyzed adoption cases of different improved crops (citrus, rice) in different subnational regions of Korea (Jeju, Jeollanamdo). The study results revealed that smallholders of Jeju could adopt improved citrus without significantly endangering their households' food security thanks to an interplay of technical and non-technical factors: The characteristics of the adopted crop, land availability in the local production system, and state policies that provided farmers necessary resources and afforded them greater autonomy in pacing the improved crop adoption in Jeju. The results resonate with geographical works that have analyzed the importance of the place-based characteristics in the adoption of agro-technologies (Basu 2009; Baka 2014; Montefrio and Dressler 2016; Clay 2017).

The research in Chapter 4 (Useful plants from the wild to home gardens: Testing an ethnobotanical hypothesis in the changing land and livelihoods of Jeju province, South Korea) found that home gardens have served as a refuge site of useful wild plants in decline in the wild, their flora constituting a significant proportion of all locally used wild plants. The useful plants in home gardens were of higher use value than the plants that did not occur in the gardens, suggesting that home gardens serve as a "cabinet" of useful plants functionally important in local culture (Finerman and Sackett 2003). Assessing an environment-society hypothesis currently under debate that centers on ethnobotany, it was found that villages with more wild lands tended to have more wild plants in home gardens, suggesting that such villages allow greater human-nature engagement, sustaining more sophisticated plant use knowledge. The result resonates with geographic and non-geographic works that have found the cultural landscape, defined as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (Plieninger and Bieling 2012)", to have intimate relations with agrobiodiversity of the crop field and the home gardens in the landscape (Van der Stege, Vogl-Lukasser, and Vogl 2012; Zimmerer 2014). There were ongoing reductions in forest cover and human-nature engagement in Jeju due to land, livelihood, and lifestyle changes in the region. Such changes, happening in many rural locales in the world (e.g., Luczaj et al. 2012), can lead to further loss of ethnobotanical knowledge and human-mediated conservation of useful wild plants.

Across the chapters, the investigation of this dissertation has demonstrated that, due to various processes of agrarian transformations, local people in Jeju have been facing challenges to the continued cultivation of crops and other useful plants in crop fields and home gardens in the traditional form. Despite the overall decline of the home garden plant cultivation practice and a reduction in farmer-held agrobiodiversity in general, the home garden remained an important production and agro- and wild- biodiversity site. The home gardens were adaptable to the commercial and subsistence needs of the household amid land-scarce situations. The agro- and wild biodiversity in home gardens was often "rescued" from the crop fields and wild and semi-wild habitats in the surrounding lands when the garden tenders faced difficulties in continuing to exploit the plants with changes in the land and livelihoods. The home garden tending was intimately linked to field agriculture amid livelihood diversification: The planting materials were largely sourced from the same sources (professional breeders), and the households with higher crop diversity in crop fields managed higher home garden plant diversity. Geographical factors like the elevation and the proportion of wild lands in the village positively affected plant diversity in home gardens, indicating the importance of landscape- and community-level factors that may affect the needs and capacities to manage diverse plants in their home gardens.

5.2 Key contributions to the literature

Geographers have studied home gardens as a production and agrobiodiversity site for food plants, medicinal plants, and other useful plants that can be vital for food security and the maintenance and reproduction of cultural identity and social networks (Kimber 1966, 2004; WinklerPrins 2002; Ban and Coomes 2004; Christie 2004; Doolittle 2004; Head, Muir, and Hampel 2004; Perreault 2005; Kortright and Wakefield 2011). Drawing on environment–society geography and cognate fields, this dissertation has critically investigated the history and roles of home gardens as agrobiodiversity sites in Jeju, South Korea (1970–2016), revealing complexities that need to be considered if home gardens are to be utilized in future development interventions (as suggested in FAO n.d.; also see Pritchard et al. 2019).

The dissertation begins the environment-society geographic study in South Korea (and possibly in all of industrialized East Asia) of home gardens, agrobiodiversity, and rural development. This region has been seriously neglected in the study of in situ agrobiodiversity, despite its unique agrarian and political-economic contexts that merit individualized attention. Important non-geographic works on home gardens have recently been conducted in East Asian locales, analyzing factors that influence the gardens' roles in food production (Clarke et al. 2014; Kamiyama et al. 2016) and in strengthening social relations in rural areas (Kamiyama et al. 2016). My dissertation draws upon these previous works in confirming the importance of food provisioning by East Asian home gardens and the urbanization-led loss of social integrity among rural communities that negatively affects home garden plant cultivation practices in the region. However, little attention has been paid to the wider processes involved in home garden plant cultivation practice: rural processes that transform rural land and livelihoods to affect home gardens' agrobiodiversity and composition, or how the home garden operates as a node in the network of agrobiodiversity sites in surrounding lands. Analyses of such processes and their impact on home garden agrobiodiversity require geographic intervention.

To address these gaps, this dissertation studies home garden agrobiodiversity of Jeju in the context of general agro- and wild-biodiversity management by local people, drawing upon the geographic literature (e.g., Coomes and Ban 2004). This dissertation contributes to the literature by advancing a step to relate this management to agrarian (and post-agrarian) transformations that have affected the local land and livelihoods. The findings reveal recompositions and reconfigurations of agrobiodiversity in the farming systems and the wider landscape that have allowed local people to exploit new opportunities and adapt to the undesired consequences of such transformations.

Additionally, the South Korean rural development in the 1970s, generally assessed as a success by the government and by Korean citizens alike, has been critically studied by sociologists, political scientists, and economists (Brandt 1979; Burmeister 1990b, 1990a; Boyer and Ahn 1991; Hwang 2006; Koh 2006; W. Kim 2019) and government studies scholars (H. S. Kim 2000; Looney 2012). The scholars, however, have mainly analyzed the state-society relationship and the effectiveness of the state programs in achieving the desired economic outcomes and general well-being of the rural people. Geographers have recently provided critiques of the Korean government's attempt from the 2010s to export the country's rural development experience in the 1970s as a model for developing countries (Doucette and Müller 2016; Jeong 2017), but these analyses have mainly addressed the political dimension of the development and its later promotion, rather than the biophysical dimensions.

The dissertation is significant to the research and practice of state-led development in Korea and in industrial East Asia because it shows the ramifications of and local responses to such development from an environment-society perspective. As mentioned above, previous studies of the topic have focused mainly on the political and social impacts of such development. While these studies have succeeded in illustrating the social subjectification and marginalization of local people that have resulted from Korean rural development (e.g., Hwang 2006; Koh 2006; W. Kim 2019), this dissertation goes beyond whether the development was politically positive or negative and shows how farmers managed natural resources, including agrobiodiversity, to respond to the new opportunities and challenges posed by such development. The comparison of regions that have received varied state development interventions also demonstrates the complexities of the "state-led development," which unfolded differently according to the state-region relationship and other regional and local factors.

The following shows this dissertation's engagement with and contribution to geographic and non-geographic works on home gardens and agrobiodiversity. Non-geographic works are specifically indicated.

Chapter 2 explores the place of home gardens in the livelihoods of rural households of Jeju in 2015, where agricultural commercialization was in its advanced stage and livelihood diversification was ongoing. The result confirms that home gardens serve as important production and agrobiodiversity sites for food, medicinal, and other useful plants, as geographers have found around the world (WinklerPrins 2002; Ban and Coomes 2004; Perreault 2005; Perrault-Archambault and Coomes 2008; Abizaid, Coomes, and Perrault-Archambault 2016), and contributes to the literature by revealing conditions for higher agrobiodiversity in such gardens (notably, the presence of non-farm income, higher crop field crop diversity of households, and the higher elevation of the home garden location). At the same time, field agriculture and the home gardens of the households were intimately linked, rather than being independent endeavors, confirming Ban and Coomes (2004) and revealing another aspect of how the two are linked (e.g., a statistical relationship between the two agrobiodiversities). In previous geographic studies, ethnically-based cultural identity was identified as the driver of home garden tenders' cultivation of plants in their gardens (e.g., Perreault 2005). In Jeju, it was the home garden tenders' cultural identity as farmers (as seen in Reyes-García et al. 2012's anthropological work) that made them more likely than other rural residents to adopt home garden plant cultivation practices. The farmers regard "food-growing" as an essential part of their identity as farmers, making home gardens a site of cultural reproduction of their identity.

Comparing different subnational regions of Korea that differ in their farming systems and main crops (Jeju and Jeollanamdo as representative of Korean rice-growing regions), Chapter 3 assesses the Korean state's multidimensional roles in agrarian development, rather than depicting the roles as uniformly positive or negative. The chapter provides an assessment of varied state interventions and their outcomes regarding agrarian development by crop (rice and citrus) and by subnational region, drawing from studies in the geographic tradition of the state's roles in natural resource management (Roth 2008; de L.T. Oliveira 2013) to analyze the previously neglected region of East Asia from environment–society geography. Employing a political ecology approach, the chapter analyzes the characteristics of traditional and newly adopted crops, local production systems, state policies, and the political-economic context of the agrarian development in the two regions in an integrated fashion. The chapter demonstrates the importance of these factors in the apparently successful outcomes of Jeju's improved crop adoption, previously credited to smallholders' tenacity, the effectiveness of state campaigns, or the technical characteristics of the crop. In doing so, the study draws upon geographical critiques of the promotion of pro-wasteland cash crops (Baka 2014; Montefrio and Dressler 2016) to advance a more contextualized understanding of the compatibility of the crops with the existing land use systems. This chapter advises against viewing the development success as purely technical and therefore universally applicable in other contexts (Baka 2014; Doucette and Müller 2016), while acknowledging the partial success of state interventions in raising the income and well-being of local people. The chapter also highlights the versatile roles of home gardens in land scarcity amid the improved crop adoption that was partly responsible for the positive outcome: The gardens served as both subsistence and commercial production land to fit the household's diverse needs during the associated land and livelihood changes.

Chapter 4 contributes to the geographic investigation of home gardens within the wider network of the sites where the plants are collected and managed (Ban and Coomes 2004) by expanding the investigation to wild and semi-wild plant habitats in the surrounding lands, finding that a significant portion of the locally used wild plants was being cultivated in Jeju home gardens, confirming their role as a reserve of biodiversity and the associated knowledge. The chapter also demonstrates that the wild and semi-wild land cover in the surrounding lands is positively correlated with the diversity of wild plants in home gardens, showing that localities that geographically allow closer contact with nature tend to develop closer relationships with the plants, indicating the potential importance of the cultural landscape in field agrobiodiversity (Zimmerer 2014) and cultivated plant diversity of home gardens, as suggested in non-geographic works (Van der Stege, Vogl-Lukasser, and Vogl 2012; Alcudia-Aguilar et al. 2018). The investigation concludes that home garden cultivation is often an adaptive behavior to secure a supply of the plants, suggesting that home gardens can facilitate the resilience of these plants via biodiversity when their populations are dwindling or they are becoming less accessible due to land development and associated livelihood changes. The conclusion thus contributes additionally to those of non-geographic works around the world that have investigated the role of home gardens in improving resilience (Aguilar-Støen, Moe, and Camargo-Ricalde 2009; Buchmann 2009; Van der Stege, Vogl-Lukasser, and Vogl 2012).

5.3 Future work

This dissertation's study results reveal that Jeju home gardens were functioning as the highest agrobiodiversity sites in the local landscape, harboring an important portion of the wild and agro-biodiversity, both during agrarian transformations and after fundamental changes in the local land and livelihoods. Nevertheless, with the agricultural commercialization and livelihood diversification, there has been a narrowing of the rural population with the knowledge and lifestyle to cultivate plants in home gardens for subsistence, and farmer-held agrobiodiversity has been largely lost. The local people, however, have generally viewed the improved crop adoption and associated developments as highly positive due to the economic growth and food security it brought them. Traditional subsistence farming systems before the 1970s, although of higher infraspecific agrobiodiversity, were associated with the abject poverty of the time and are not missed by the people. The question then arises: What can plant cultivation in home gardens and other subsistence sites do for Jeju people now when in general they do not seem to be in dire need of subsistence production for food security? This question is important because in situ agrobiodiversity conservation can only happen when it serves the cultivators of agrobiodiversity in important ways.

Accordingly, this dissertation's results have demonstrated aspects of the benefits of home garden agrobiodiversity that are relevant in industrialized contexts, including the germplasm conservation of important local plants. Some of the findings signal the need for further studies. For example, Jeju had areas where fresh food was not available from the in-village supermarket ("mid-hill villages" in Chapter 2) whose residents thus needed home food growing. The "food deserts" (McClintock 2011), however, may have different policy implications in Jeju or in other parts of East Asia and may not have a similar geographic pattern as in the better-researched parts of the First World (e.g., metropolitan cities of the United States), which can be an area for further research. In addition, a significant amount of subsistence legumes were being cultivated in home gardens in Jeju. Legumes made up the largest accessions of landrace in Jeju and the nation (National Agrobiodiversity Center 2016). This food group, highly important in Asian cuisine and culture in general, can be a starting point for in situ agrobiodiversity studies in the East Asian region. Also, the home gardens harbored large amounts of leafy and other vegetables, whose nutritional benefits would be important to Jeju people, who generally have a more than sufficient caloric intake but whose diet has been moving away from the traditional vegetable-rich diet, becoming nutritionally imbalanced. The province, unfortunately, had the highest rate of obesity in the nation (38.6%) and a vegetable intake lower than the national average as of 2019 (Jeju Special Self-Governing Province 2019). Analysis of nutritional quality and the associated cultural dimensions that legume and vegetable agrobiodiversity can provide can constitute another area of study as one of the core components of agrobiodiversity (Zimmerer 2014).

Agrobiodiversity governance of locales in Korea and other East Asian countries can be another area of future work. As noted in the earlier part of this chapter, Jeju had weakly developed between-farmers exchange networks of planting materials. To promote in situ agrobiodiversity conservation in places like Jeju, farmer engagement strategies will have to be substantially reimagined. Landrace NGOs were newly formed in the early to mid-2010s in Jeju but they did not yet seem to be well-known or well-utilized among a broad spectrum of Jeju farmers as of 2015, who typically resorted to professionally-bred seeds or self-kept family seeds.

The effectiveness of whatever channel may prove most appropriate for farmer engagement in in situ agrobiodiversity conservation may hinge upon the influence of various factors in farmers' decisions between government extension agents, farmers' associations, and seed exchange NGOs. The historical relationships formed with farmers in the region can affect how successful their interventions are: The same actor (e.g., state government) may h affect farmers' decisions in some cultural contexts and not in others.

In assessing Jeju's agrarian transformations via political ecology, this dissertation has revealed complexities in local cultural ecology and the political-economic contexts at wider scales that cannot be simply replicated and prescribed in future development interventions (Doucette and Müller 2016). The utilization of home gardens was a part of the people's flexible and individualized adaptation to the opportunities and challenges amid a reorganization of production systems, which could not be foreseen and prescribed in development planning from the state's perspective. The South Korean state's agrarian policies in the 1970s (e.g., extreme trade restrictions), although partially effective at the time, may not be replicable in today's international trade contexts, which have been liberalizing. However, considering Jeju's generally positive experience in agrarian developments, the study suggests that the state's role in development may not always be rigid (Scott 1998) or politically self-serving (Ferguson 1994; Li 2007). The state development efforts may indeed converge with the smallholders' desires and produce desirable results in some contexts, especially when greater farmer autonomy is allowed. Environment-society geography has made important contributions to revealing where and how such convergence happens (e.g., Roth 2008). The integrative approach of the subfield can provide greater insight into new forms of cash-crop introductions (e.g., biofuel) and other agrarian developments involving state and smallholders currently happening in the world.

5.4 References

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Appendix

List of all cultivated plant taxa from Jeju home gardens (n = 131)

No.	Botanical name	English Common name	Family	Frequency	Abundance	Life form	KPNI category	Plant use			
								Edible (Food group)	Me	Or	Ot
1	*Capsicum annuum*	Chili	Solanaceae	105	3637	A/P	D	2 (OV Sp)			
2	*Perilla frutescens* var. *japonica*	Perilla	Lamiaceae	67	3184	A	D	3 (LV LNS OF)			Cr
3	*Glycine max*	Soy	Fabaceae	39	2637	A	D	2 (LV LNS)			Fo, Ri
4	*Lactuca sativa*	Lettuce	Asteraceae	69	1810	A	D	1 (LV)	Me		
5	*Allium tuberosum*	Chive	Liliaceae	50	1840	p	D	1 (LV)	Me		
6	*Phaseolus vulgaris*	Common bean	Fabaceae	20	2289	A	D	2 (LV LNS)			
7	*Cucurbita moschata*	Asian pumpkin	Cucurbitaceae	62	1038	A	D	2 (LV OV)	Me		Ri
8	*Cucumis sativus*	Cucumber	Cucurbitaceae	62	998	A	D	1 (OV)	Me		Ri
9	*Brassica rapa*	Asian cabbage	Brassicaceae	35	1470	B	D	1 (LV)	Me		Ri
10	*Allium sativum*	Garlic	Liliaceae	14	1711	A/P	D	1 (OV)	Me		
11	*Zingiber mioga*	Myoga ginger	Zingiberaceae	30	1208	P	D	2 (LV OV)	Me		Ri
12	*Allium fistulosum*	Green onion	Liliaceae	43	814	A/P	D	3 (LV OV Sp)			Ri
13	*Ipomoea batatas*	Sweet potato	Convolvulaceae	23	1268	P	D	2 (LV WRT)			Fo, Ri
14	*Solanum melongena*	Eggplant	Solanaceae	53	501	P	D	1 (OV)			
15	*Diospyros kaki*	Oriental persimmon	Ebenaceae	65	118	T	N	2 (F Sp)	Me		Cr, Dy
16	*Zea mays*	Corn	Poaceae	19	1019	A	D	1 (OV)	Me		
17	*Lycopersicon esculentum*	Tomato	Solanaceae	35	432	A	D	1 (OV)	Me		
18	*Sesamum indicum*	Sesame	Pedalidaceae	9	1070	A	D	2 (LNS OF)	Me		Ri, Ot
19	*Raphanus sativus*	Radish	Brassicaceae	19	569	A/B	D	2 (LV OV)	Me		Ri
20	*Citrus unshiu*	Satsuma mandarin	Rutaceae	29	77	T	D	2 (F Sp)	Me		Ne, Ri
21	*Allium x proliferum*	Tree onion	Liliaceae	12	458	A/P	D	3 (LV OV Sp)			
22	*Camellia japonica*	Common camellia	Theaceae	24	100	T	N	1 (OF)	Me	Or	Dy, Ot

23	*Fragaria × ananassa*	Strawberry	Rosaceae	6	475	P	D	1 (F)			
24	*Citrullus vulgaris*	Watermelon	Cucurbitaceae	15	230	A	D	1 (F)	Me		Ri
25	*Colocasia esculenta*	Taro	Araceae	17	176	P	D	2 (LV WRT)	Me		
26	*Peucedanum japonicum*	Coastal hogfennel	Apiaceae	16	186	P	N	1 (LV)	Me		
27	*Codonopsis lanceolata*	Deodeok	Campanulaceae	11	309	P	N	1 (WRT)	Me		
28	*Platycodon grandiflorum*	Balloon-flower	Campanulaceae	12	274	P	N	1 (WRT)	Me		
29	*Oenanthe javanica*	Java water-dropwort	Apiaceae	11	280	P	N	1 (LV)	Me		Ri
30	*Cucumis melo* var. *makuwa*	Korean melon	Cucurbitaceae	9	317	A	D	1 (F)	Me		
31	*Solanum tuberosum*	Potato	Solanaceae	7	325	P	D	1 (WRT)	Me		Ri
32	*Glebionis coronaria*	Crown daisy	Asteraceae	11	171	A/B	D	1 (LV)			
33	*Ficus carica*	Common fig	Moraceae	16	25	S	D	1 (F)	Me		
34	*Zanthoxylum piperitum*	Korean pepper	Rutaceae	16	20	S	N	1 (Sp)	Me		Ot
35	*Vigna radiata* var. *radiata*	Mung bean	Fabaceae	3	330	A	D	1 (LNS)	Me		
36	*Plantago asiatica*	Asian plantain	Plantaginaceae	2	310	P	N	1 (LV)	Me		
37	*Cucurbita pepo*	Summer squash	Cucurbitaceae	8	151	A	D	2 (LV OV)			
38	*Ziziphus jujuba* var. *inermis*	Korean date	Rhamnaceae	13	16	S	D	1 (F)	Me		Ri
39	*Chicorium intybus*	Leaf chicory	Asteraceae	7	149	P	D	1 (LV)			
40	*Vaccinium corymbosum*	Highbush blueberry	Ericaceae	11	35	S	D	1 (F)			
41	*Arachis hypogaea*	Peanut	Fabaceae	6	152	A	D	1 (LNS)			
42	*Impatiens balsamina*	Garden balsam	Balsaminaceae	4	200	A	D			Or	
43	*Pisum sativum*	Pea	Fabaceae	4	200	A	D	1 (LNS)	Me		
44	*Aloe vera*	Aloe vera	Asphodelaceae	11	24	P	D	1 (OV)			

45	*Polygonatum odoratum* var. *pluriflorum*	Lesser solomon's seal	Asparagaceae	9	65	P	N	1 (Sp)	Me		
46	*Eriobotrya japonica*	Loquat	Rosaceae	11	12	T	D	1 (F)	Me		
47	*Prunus tomentosa*	Nanking cherry	Rosaceae	11	12	S	D	1 (F)			
48	*Vigna angularis* var. *angularis*	Red bean	Fabaceae	4	180	A	D	1 (LNS)			Ri
49	*Houttuynia cordata*	Fish mint	Saururaceae	4	177	P	E		Me		
50	*Pyrus pyrifolia*	Asian pear	Rosaceae	10	13	T	D	1 (F)	Me		Ri
51	*Citrus natsuidaidai*	Amanatsu citrus	Rutaceae	10	12	T	D	1 (F)			
52	*Helianthus annuus*	Sunflower	Asteraceae	7	87	A	D	1 (LNS)		Or	
53	*Malus pumila*	Apple	Rosaceae	9	14	T	D	1 (F)			Ri
54	*Prunus mume*	Chinese plum	Rosaceae	9	13	T	D	1 (F)	Me		
55	*Allium cepa*	Onion	Liliaceae	5	95	A/P	D	1 (OV)	Me		Dy
56	*Vitis vinifera*	Common grapevine	Vitaceae	8	11	C	D	1 (F)			Ri
57	*Prunus persica*	Peach	Rosaceae	8	9	T	D	1 (F)	Me		
58	*Spinacia oleracea*	Spinach	Amaranthaceae	5	70	A	D	1 (LV)	Me		
59	*Zingiber officinale*	Ginger	Zingiberaceae	4	90	P	D	2 (OV Sp)	Me		
60	*Aster scaber*	Edible aster	Asteraceae	4	60	P	N	1 (LV)	Me		
61	*Morus alba*	White mulberry	Moraceae	6	7	S	D	1 (F)	Me		Cr
62	*Capsicum annuum*	Bell pepper	Solanaceae	4	47	A/P	D	1 (OV)	Me		
63	*Farfugium japonicum*	Leopard plant	Asteraceae	5	18	P	N			Or	
64	*Sedum sarmentosum*	Stonecrop	Crassulaceae	2	90	P	N	1 (LV)	Me		
65	*Helianthus tuberosus*	Jerusalem artichoke	Asteraceae	3	60	P	E	1 (WRT)			
66	*Kochia scoparia* var. *scoparia*	Smotherweed	Amaranthaceae	4	33	A	D		Me		
67	*Aralia elata*	Korean angelica tree	Araliaceae	5	5	T	N	1 (LV)	Me		
68	*Daucus carota*	Carrot	Apiaceae	1	100	A	D	1 (OV)	Me		

69	*Dioscorea batatas*	Chinese yam	Dioscoreaceae	1	100	P	N	1 (WRT)	Me		
70	*Artemisia princeps*	Korean wormwood	Asteraceae	1	100	P	N	1 (Sp)	Me		In
71	*Mentha × piperita*	Peppermint	Lamiaceae	1	100	P	D	1 (Sp)			
72	*Rosmarinus officinalis*	Rosemary	Lamiaceae	4	23	P	D	1 (Sp)			
73	*Brassica napus*	Rapeseed	Brassicaceae	2	70	B	N	2 (LV, OF)		Or	Cr, Ne
74	*Ligularia fischeri*	Fischer's ragwort	Asteraceae	3	41	P	N	1 (LV)	Me		
75	*Opuntia ficus-indica*	Prickly pear	Cactaceae	4	15	P	D		Me		
76	*Taraxacum platycarpum*	KoreanDandelio n	Asteraceae	3	37	P	N	1 (LV)	Me		
77	*Mentha L.*	Mint	Lamiaceae	3	35	P	D	1 (Sp)	Me		In
78	*Beta vulgaris* var. *saccharifera*	Beetroot	Amaranthaceae	3	32	B	D	2 (LV OV)			
79	*Malus asiatica*	Chinese pearleaf crabapple	Rosaceae	4	6	T	D	1 (F)			
80	*Citrus sinensis*	Sweet orange	Rutaceae	4	4	T	D	1 (F)	Me		Ri
81	*Lonicera japonica*	Honeysuckle	Caprifoliaceae	2	52	C	N		Me		Ri
82	*Fallopia multiflora*	Tuber fleeceflower	Polygonaceae	3	25	P	D		Me		
83	*Momordica charantia*	Bitter gourd	Cucurbitaceae	3	24	A	D	1 (OV)			
84	*Luffa cylindrica*	Sponge gourd	Cucurbitaceae	3	14	A	D	1 (OV)	Me		
85	*Senna tora*	Sickle Senna	Fabaceae	3	12	A	D	1 (Sp)	Me		
86	*Brassica oleracea* var. *acephala*	Kale	Brassicaceae	2	35	B	D	1 (LV)			
87	*Ricinus communis*	Castorbean	Euphorbiaceae	3	9	A	D	1 (LV)			
88	*Beta vulgaris* var. *cicla*	Chard	Amaranthaceae	2	30	B	D	1 (LV)			
89	*Dahlia pinnata*	Dahlia	Asteraceae	2	30	A	D			Or	
90	*Apium graveolens*	Celery	Apiaceae	2	30	P	D	1 (OV)			
91	*Elaeagnus umbellata*	Autumn olive	Elaeagnaceae	3	3	S	N	1 (F)	Me		Cr, Ot

92	*Punica granatum*	Pomegranate	Lythraceae	3	3	T	D	1 (F)	Me		Dy
93	*Kalopanax septemlobus*	Prickly castor oil tree	Araliaceae	3	3	T	N	1 (LV)	Me		Cr
94	*Allium monanthum*	Korean wild chive	Liliaceae	1	50	P	D	2 (OV Sp)	Me		
95	*Neolitsea aciculata*	Irregular-streak newlitse	Lauraceae	2	24	T	N		Me		Cr
96	*Pimpinella brachycarpa*	Chamnamul	Apiaceae	2	21	P	N	1 (LV)			
97	*Artemisia annua*	Sweet wormwood	Asteraceae	1	40	A	N				
98	*Agastache rugosa*	Korean mint	Lamiaceae	2	14	P	N	1 (Sp)			
99	*Ulmus davidiana* var. *japonica*	Wilson's elm	Ulmaceae	2	11	T	N	1 (Sp)	Me		Ot
100	*Glycyrrhiza uralensis*	Chinese liquorice	Fabaceae	2	9	P	D		Me		
101	*Salvia plebeia*	Plebeian sage	Lamiaceae	2	8	A/B	N	1 (LV)			
102	*Aronia melanocarpa*	Black chokeberry	Rosaceae	2	8	S	D	1 (F)			
103	*Polygonatum odoratum* var. *pluriflorum* f. *variegatum*	Variegate lesser solomon's seal	Asparagaceae	2	7	P	N			Or	
104	*Chrysanthemum morifolium*	Garden mum	Asteraceae	1	30	P	D			Or	
105	*Pharbitis nil*	Japanese morning glory	Convolvulaceae	1	30	A	D			Or	
106	*Ilex rotunda*	Round-leaf holly	Aquifoliaceae	2	4	T	N		Me	Or	
107	*Fortunella japonica*	Kumquat	Rutaceae	2	3	S	D	1 (F)	Me		
108	*Paeonia lactiflora*	Peony	Paeoniaceae	2	3	P	D			Or	
109	*Acer palmatum*	Palmate maple	Sapindaceae	2	2	T	N		Me	Or	

110	*Vitis coignetiae*	Crimson grapevine	Vitaceae	2	2	C	N	1 (F)			Cr
111	*Chaenomeles sinensis*	Chinese quince	Rosaceae	2	2	T	D	1 (F)	Me		
112	*Cornus kousa*	KoreanDogwood	Cornaceae	2	2	T	N	1 (F)			
113	*Gardenia jasminoides*	Gardenia	Rubiaceae	2	2	S	D		Me		Ot
114	*Celtis sinensis*	East Asian hackberry	Cannabaceae	2	2	T	N	1 (F)			
115	*Psidium guajava*	Common guava	Myrtaceae	2	2	S	D	1 (F)			
116	*Daphne kiusiana*	WhiteDaphne	Thymelaeaceae	2	2	S	N			Or	
117	*Hemerocallis fulva*	OrangeDay-lily	Asphodelaceae	1	20	P	D	1 (LV)	Me	Or	
118	*Angelonia angustifolia*	Angelonia	Plantaginaceae	1	20	P	D				
119	*Brassica oleracea* var. *capitata*	Cabbage	Brassicaceae	1	20	B	D	1 (LV)			
120	Perilla frutescens var. crispa	Shiso	Lamiaceae	1	10	A	D	1 (LV)	Me		
121	*Aralia cordata*	Spikenard	Araliaceae	1	10	P	D	1 (LV)			
122	*Ocimum basilicum*	Basil	Lamiaceae	1	10	A	D	1 (Sp)			
123	*Allium hookeri*	Hooker chive	Liliaceae	1	10	p	D	1 (LV)			
124	*Canavalia ensiformis*	Sword bean	Fabaceae	1	10	A/P	D	1 (LNS)			
125	*Fatsia japonica*	Glossy-leaf paper plant	Araliaceae	1	7	S	N			Or	
126	*Ixeridium dentatum*	Toothed ixeridium	Asteraceae	1	5	P	N	1 (LV)	Me		
127	*Wisteria floribunda*	Japanese wisteria	Fabaceae	1	5	C	N			Or	
128	*Echinodorus cordifolius*	Spade-leaf sword	Alismataceae	1	5	P	D			Or	
129	*Hydrocleys nymphoides*	Water poppy	Alismataceae	1	5	P	D			Or	
130	*Allium microdictyon*	Wild onion	Liliaceae	1	5	P	N	1 (LV)			
131	*Nelumbo nucifera*	Lotus	Nelumbonaceae	1	5	P	D			Or	

132	*Portulaca grandiflora*	Ross moss	Portulacaceae	1	5	A	D			Or	
133	*Smallanthus sonchifolius*	Yacon	Asteraceae	1	3	P	D	1 (WRT)			
134	*Lycium chinense*	Chinese wolfberry	Solanaceae	1	2	T	D	2 (F Sp)	Me		
135	*Viola mandshurica*	Manchurian violet	Violaceae	1	2	P	N		Me	Or	
136	*Rhododendron mucronulatum*	Korean rhododendron	Ericaceae	1	2	S	N	1 (Sp)		Or	
137	*Rhododendron schlippenbachii*	Royal azalea	Ericaceae	1	2	S	N			Or	
138	*Astragalus mongholicus*	Hwang-gi (Mongolian milkvetch)	Fabaceae	1	2	P	N				
139	*Eleutherococcus senticosus*	Devil's bush	Araliaceae	1	1	S	N		Me		
140	*Pteridium aquilinum* var. *latiusculum*	Eastern brackenfern	Dennstaedtiaceae	1	1	P	N	1 (OV)	Me		Ri
141	*Abies koreana*	Korean fir	Pinaceae	1	1	T	N				
142	*Cudrania tricuspidata*	Silkworm thorn	Moraceae	1	1	T	N	1 (F)	Me		Cr, Fo
143	*Rubus coreanus*	Korean black raspberry	Rosaceae	1	1	S	N	1 (F)	Me		
144	*Torreya nucifera*	Nut-bearing torreya	Taxaceae	1	1	T	N		Me		In, Ri
145	*Prunus armeniaca* var. *ansu*	Ansu apricot	Rosaceae	1	1	T	D	1 (F)	Me		
146	*Eleutherococcus sessiliflorus*	Stalkless-flower eleuthero	Araliaceae	1	1	S	N		Me		
147	*Toxicodendron vernicifluum*	Chinese lacquer tree	Anacardiaceae	1	1	T	D	1 (Sp)	Me		
148	*Citrus junos*	Yuja (Yuzu)	Rutaceae	1	1	T	D	1 (F)	Me		