Doctoral Thesis

Geographical Study on the Mechanisms of Farmland Abandonment in Japan

--Determinants and Countermeasures

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March 2020

ABSTRACT

Agriculture has been the mainstay for the livelihood of rural people for centuries. By engaging in agriculture and utilizing the various natural resources of farmland, people had known how to produce food and to fight with hunger. In many developed and developing countries, agriculture also played major roles in economic growth and contributed largely to the GDP. In addition, agricultural practices are crucial in the preservation of natural resources. Through continuous agricultural activities, environmental risks can be reduced, and economic damages caused by natural hazards can also be prevented. The extent of agriculture is expected to increase globally with the increase of the world population. However, in recent years, the decline of agriculture and loss of farmland area are occurring. In many countries, agriculture areas have decreased as a result of farmland abandonment (FLA), which is an irreversible process, changing with the influence of various environmental or socio-economic conditions. Such development has caused significant unfavorable natural and socio-economic consequences for both farmers and the society. Therefore, a clear understanding of farmland usage and dynamics is essential for maintaining the stability and sustainability of the ecosystem. The author focuses on FLA in Japan which is a serious issue and try to reveal the mechanisms of FLA from different perspectives.

In the past three decades, Japan has undergone an unprecedented decline of agriculture chiefly due to the aging of farmers, depopulation, and unfavorable socio-economic conditions. The issue of FLA has been investigated from the early 1990s. FLA studies in terms of geographical contexts have greatly diversified over the past few decades. Mountainous areas have firstly experienced the trend of FLA and it spread to suburban and plain areas. In mountainous areas, the agricultural activities have always been restricted by unfavorable conditions such as geographical situation and accessibility. This development has not only resulted in the increase of FLA but also has had negative impacts on livelihood of farmers and food security. However, this phenomenon remains ill-understood in East Asia, particularly in heavily depopulated and aging countries, such as Japan. As such, this research mainly focuses on Japan and tries to fill this gap by revealing the mechanisms of FLA at multiple scales.

This study attempts to shed empirical light on the temporal and spatial patterns, determinants and countermeasures of FLA in Japan from the national, regional and local contexts. The analysis follows the following steps: FLA and farmland use changes; determinants and mechanisms; consequences; countermeasures and policy implications, which provides rich

information of FLA under different geographical and socio-economic circumstances. The study is divided into the national (the whole Japan), the regional (the Chugoku and Shikoku region) and the local (Hiroshima Prefecture) scales. For the analysis, the author employed both qualitative and quantitative methodologies. On the one hand, the author employed the former municipalities defined in 1950 at a national scale as unit samples to conduct quantitative analyses from the national and regional scales. Consequently, the spatial patterns, characteristics, variations of FLA and agricultural characteristics in Japan were displayed. As for the drivers or determinants, the author primarily adopted Multiple Linear Regression (MLR), Geographically Weighted Regression (GWR) and Principal Component Analysis (PCA) as methodologies. A set of variables retrieved from the census of agriculture and forestry were selected to evaluate the determinants of FLA from the global and local regressions. On the other hand, the author carried out questionnaire surveys and interviews at the local scale to know the real local situation of FLA. Individual farm households and Incorporated Community-Based Farm Cooperatives (ICBFCs) were selected to examine the farmers' awareness of FLA and future agricultural development. The combination of different scales and methodologies allow us to understand FLA comprehensively.

The main findings are as follows: From national scale, the author has found that, first, FLA in Japan exhibits a significantly uneven pattern. While taking the (Farmland Abandonment Rate) FLAR as a measurement, the results demonstrate that most abandoned farmland is positively correlated with slope and is highly clustered in the Kanto, Chubu and Chugoku Shikoku regions, compared to other regions that are suitable for agricultural production, such as the Hokkaido and Tohoku regions. Second, the arable land ratio of self-sufficient farm households and the ratio of non-successor farm households positively affect abandonment. In contrast, the number of laborers per farm household, arable land area per farm household and paddy field density have a negative impact on abandonment. Third, the determinants are spatially varied among study regions. FLA is driven by interactions of multiple determinants and depends on specific local circumstances.

From intraregional scale, the author has found that, first, there are strong intraregional differences in the agricultural characteristics across the Chugoku and Shikoku region, with eight different principle components (PCs) describing the characteristics. Second, variables measuring agricultural characteristics explain nearly 52.8% of the variation in FLA in our sample. The sales orientation and scale of agriculture have the strongest negative correlation to FLA in the region, while the status of agricultural succession displays the strongest positive correlation to FLA. Third, in areas where agriculture is more stable and easier to maintain, FLA is more strongly influenced by changes in agricultural characteristics than by geographical variations. The author argues that localized approaches and policies for future management need to take intraregional differences in agricultural characteristics and FLA into account. The findings help to explain spatial variations in agricultural characteristics and FLA in regional contexts, suggesting the need for better-informed farmland use policies to mitigate further abandonment.

From the local scale, the author has found that first, the three main reasons for local farm households to abandon their farmland, include lack of successors, lack of sufficient laborers, and aging of farmers. For ICBFCs, the major determinants are lack of successors, aging of farmers, and low profit from agriculture production. Labor conditions are more significant for individual farm households while the economic situation of ICBFCs is the key to solving for FLA. Second, most farm households and ICBFCs exhibited a negative attitude to FLA. An inverse correlation between FLA and ICBFCs at the municipality level suggested ICBFCs do have an effective role in preventing FLA. In addition, more financial support from the government is required to manage future FLA. ICBFCs can mainly contribute to agriculture development in two regards. ICBFCs can strengthen connections and communications among local farmers; and agriculture skills can also be improved through periodic workshops. On the other hand, ICBFCs can also improve the working efficiency and ensure the adequacy of labor conditions by intensive management. Third, regarding future development, individual farm households are more concerned about labor conditions, and ICBFCs regard the financial situation as more significant. Financial and labor conditions are key issues for sustainable ICBFC management. Many ICBFCs also expressed a desire for mutual support from the government and farmland management organizations. Meanwhile, they also expect more of the young generation to return to the rural areas.

The findings help to explain the temporal and spatial patterns, determinants, regional variations and countermeasures of FLA at the national, intraregional and local contexts. The outcome generates a comprehensive understanding of FLA across the study region and, therefore, culminates in some recommendations for future farmland use and agriculture development. Japan’s case is a significant empirical example for the supplemental understanding of FLA in general and for those who want to thoroughly examine agriculture in a heavily aging and depopulated society especially in rural areas. Such results also have derived various significant insights for policymaking for the management of agriculture and countermeasures for future FLA, which are essential to promoting the maintenance of farmland and sustainable agriculture.

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LIST OF ABBREVIATIONS

CBFC Community Based Farm Cooperative

CBA Community Based Agriculture

CSA Community Supported Agriculture

DPS Direct Payment Scheme

FLA Farmland Abandonment

FLAR Farmland Abandonment Rate

GWR Geographically Weighted Regression

LULCC Land Use and Land Cover Change

LISA Local Indicators of Spatial Association

HMAs Hilly and Mountainous Areas

ICBFC Incorporated Community Based Farm Cooperative

MAFF Ministry of Agriculture, Forestry and Fishery

MLR Multiple Linear Regression

NCBFC Non-incorporated Community Based Farm Cooperative

OVOP One Village One Product

PCA Principal Component Analysis

RS Remote Sensing

SDGs Sustainable Development Goals

CHAPTER 1 INTRODUCTION

Agriculture has been the mainstay for the livelihood of rural people throughout human history. The very original function of agriculture is to produce food for people. From ancient times, people had to know how to produce food and to fight with hunger through doing agriculture and utilizing the various natural resources of farmland. Since 1990s, agriculture has developed a lot with the emergence of some new agricultural practices which enabled an unprecedented growth of population and workforce. In more recent years, agriculture started to contribute greatly to the economic prosperity in many developed and developing countries (Johnston & Mellor, 1961). For instance, in big agricultural countries like the United States and China, food has played a significant role as a fundamental economic product. Besides, economic values, economic growth in the agricultural and rural sectors has exhibited a much greater impact on poverty alleviation and hunger than urban and industrial growth (FAO, 2006). Moreover, agricultural activities can be crucial in the preservation of natural resources. Through continuous agricultural and forestry activities, environmental risks can be reduced, and economic damages caused by natural hazards can also be prevented (FAO, 2006). Furthermore, it can also be expected that agriculture has abundant cultural and social values. The dramatic development of agriculture over the last three decades not only changed the economic and social status of rural areas but have also deeply altered the natural environment through affecting the amenities of traditional landscapes and villages, as well as the integrity of agricultural ecosystems (Knickel, 1990).

Farmland, as is indispensable for farming or agriculture, plays a significant role in the Earth's ecosystems. It is important not only for agricultural production, but also for its considerable ecosystem functioning in the flora and fauna of a region (MacDonald et al., 2000; Lasanta, et al., 2015). In 2015, the United Nations initiated the Sustainable Development Goals (SDGs) to work towards a more sustainable future for the planet and society. Goal 15 targets biodiversity and life on land in an effort to ensure the conservation, restoration and sustainable use of land and ecosystem services. Sustainable land use is becoming a fundamental research topic for land use planning (Xue et al. 2019). Biodiversity plays a key role in ecosystem stability while sustainable farming and agriculture are essential to preserve natural resources and to maintain rural landscapes and communities (Díaz et al., 2011; Scherr & McNeely, 2008). Farmland takes up about 38% of Earth's ice-free terrestrial areas (Ruskule et al., 2013). These farmlands keep a balance between human needs and ecosystems. Current agricultural research and policy agendas in Europe have largely paid attention to sustainable management of farmland and natural resources (Matin et al., 2016).

In many countries, farmland areas have decreased as a result of abandonment (Li & Li, 2017), and this is becoming a reality worldwide (MacDonald et al., 2000; Rey Benayas, 2007; Eduardo Corbelle-Rico & Crecente-Maseda, 2014; Yan et al., 2016). Farmland is expected to increase globally with the increase of the world population. However, in recent years, the expansion of farmland area is not occurring to the same degree in all parts of the world. In the last 30 years, abandoned farmland has become a threat to sustainable agriculture. Besides, the impacts of abandonment are controversial as consequences vary across geographical regions and must be considered relative to the region's agricultural situations (Rey Benayas, 2007; Queiroz et al., 2014; Teodoro Lasanta et al., 2015).

Some scholars view farmland abandonment (here after: FLA) as an opportunity for habitat regeneration, with an added nature value from forests or grasslands restoration (Rey Benayas, 2007; Yang et al., 2019). Others regard abandonment as a threat to biodiversity that can cause serious environmental issues such as landscape and habitat loss, and can have direct or indirect impact on land degradation (FAO, 2006). The change of landscape can also be a higher risk to fire and less resilient ecosystems (Sil et al., 2019). Regardless of the environmental impacts, abandoned farmland can lead to reduced agricultural production and weakened socio-economic conditions in rural communities (MacDonald et al., 2000). In most regions, the FLA is an irreversible process, changing with the influence of various environmental or socio-economic situations and frequently exceeds farmland expansion (Verburg & Overmars, 2009). Such development has caused significant unfavorable natural and socio-economic consequences (A. V. Prishchepov et al., 2012; Zakkak et al., 2015). Therefore, a clear understanding of farmland usage and dynamics is essential for maintaining the stability and sustainability of the ecosystem (Kawashima, 2010; E. Corbelle-Rico et al., 2012; Xie et al., 2014).

Until now, there still lack studies on FLA in east Asia and a country who is facing serious aging such as Japan. Japan is a country that experiences heavy depopulation particularly in rural areas and the agriculture sector subsequently declines after postwar time (Okahashi, 2004). Since the higher economic growth period, Japan has been experiencing rapid out migration and aging in rural villages, which cause serious labor shortage and agriculture decline. Rural lifestyle has always been peaceful and enjoyable, and the multifunctionality of rural areas and agriculture have been evidenced to be of great economic value in general (Aizaki et al., 2006). However, rural areas and the lifestyle of rural residents are drastically changing worldwide as result of the demographic shrinkage, with dramatical impacts on rural landscapes such as settlement structure change and intensification of agriculture (Ruskule et al., 2013). For instance, a population fall in rural areas may bring about the withdrawal of living-related services, a decline in job-finding opportunities and in rural accessibility, all of which lead to further depopulation (Ministry of Agriculture, Forestry and Fishery (MAFF, 2018)).

The Japanese archipelago has very complicated geography, with many hilly and mountainous areas (HMAs) (In Japanese: *Chusankanchiiki*) distributed widely throughout the country (accounting for approximately 40% of the total agricultural areas) (Uematsu et al., &, 2010). On the one hand, in these areas, agriculture is difficult to maintain, and the shortage of labor force cannot be supplemented immediately due to the lack of agricultural successors, among other factors (Yamashita & Hoshino, 2018). These factors are the primary reasons for the existence of high FLAR, especially in rural mountain villages. On the other hand, Japan is experiencing massive depopulation and aging problems in rural areas (Heller, 2016); 26% of Japan's population is older than 65. This social background is extremely unfavorable for agriculture because the effectiveness of cultivation and the lack of labor in agriculture directly promote abandonment.

Since the 1950s, and especially after the mid-1980s, Japanese agriculture has been shrinking year by year (Hisano et al., 2018). Japan has seen an unprecedented increase in FLA since the 1990s, which not only causes serious environmental problems and rural landscape loss but also has a drastic impact on socio-economic conditions and the livelihood of Japanese farmers. Arable land contraction declined from 6.09 million hectares in 1961 to 4.52 million hectares in 2014 which has subsequently brought many socio-economic problems such as food security (MAFF). In addition, a total of 423,064 hectares of farmland have been abandoned in the one-year period of 2015 alone and the decline of farm households and agriculture labor aggregating the problem (MAFF, 2015). Based on the agriculture census, the number of farmers in Japan was 2.155 million in 2015, 373,000 (14.7%) fewer compared to 2010. In addition, the working population of business farmers (who mainly engage in self-employed agriculture) was 2.097 million. This number decreased by 509,000 (19.5%) from 2010 to 2015. Moreover, the average age of the working population in agriculture is 66.4, and the proportion of people aged 65 and over is 63.5% (MAFF, 2015). In addition to the aging issue, population outflow from rural areas and a lack of successors for farm households exacerbate the situation (Yamashita &

Hoshino, 2018). This trend can lead to further isolation and marginalization of vulnerable rural populations (FAO, 2006).

All the above-mentioned factors make it difficult to ensure agricultural succession. In addition to many external (socioeconomic condition, public policies) and internal (agroecological and the features of agricultural holdings) driving factors (T. Lasanta et al., 2015; Schneider et al., 2015), directly or indirectly aggravating the problem of FLA (Zhang et al., 2016). Thus far, many aspects are still being largely unknown. Such as temporal and spatial patterns, determinants at different scales, agriculture and FLA as well as future determinants of FLA. A comprehensive analysis of FLA from both macro and micro scales has never been evidenced in Japan. As such, it is necessary to study FLA and its mechanism by making good use of agricultural census data and by conducting surveys to understand local farm households and Incorporated Community-based Farm Cooperatives (ICBFCs) from multiple levels and perspectives.

The primary goal of this study is to explain the mechanism of FLA, its determinants as well as countermeasures. The study was conducted at three scales: first, from the national scale, an overall situation of FLA regarding its spatial-temporal patterns and determinants are displayed. Second, this study focuses on the regional scale by comparing their regional and intraregional differences regarding FLA. In this level, seven regions in Japan are considered to compare their differences regarding FLA and one specific region was selected to understand relationships between intraregional agricultural characteristics and FLA. How each specific regional circumstances and intraregional circumstances affect FLA have been explored. Third, from the local scale, the study selects individual farm households and ICBFCs as targets and tries to reveal the local farmers' awareness about FLA. All three scales can reflect the FLA more comprehensively. Japan is one of the countries that have experienced serious aging issue. For this reason, Japan's case would be a good empirical example for the understanding of FLA in general and for those who want to thoroughly examine agriculture in a heavily depopulated society. The findings also assist both central and administrative government and local farm households to manage their abandoned farmland and better utilize their agricultural resources.

1.1 Research Background

Under many unfavorable socio-economic change in rural areas, agriculture is declining due to lack of labor, and more abandoned farmland is emerging. The issue of FLA in Japan can be traced back to the early 1990s when Japanese rural areas started to stagnate due to aging and depopulation of farmers and unfavorable socio-economic changes. In mountainous areas of Japan, designated as ‘problem areas’(KASO areas or depopulated mountain villages) by the central government, typical regional depression such as restricted job opportunities, low income, higher rates of aging population and serious depopulation has progressed since the 1950s (Okahashi, 1986). Even today, most young generations and people who live in cities are far away from agriculture, thinking agricultural work is tiring and with no interests. In the face of the future of such rural areas, agriculture should be revitalized in an urgent need to attract more people to come back.

Japanese agriculture still has a lot of potential to be pursued, either nationally or internationally. Self-sufficient farming largely contributes to the increase of FLA because farm households never engaged in economic activities that fully utilize their farmland resources. The food self-sufficiency rate in Japan on a calorie basis is 39%, which is extremely low compared to other major OECD countries (Figure 1-1). In the fiscal year 2014, the self-sufficiency rate (on an item-specific weight basis) was 100 % for rice, 13 % for wheat, 10 % for beans, 80 % for vegetables, 43 % for fruits, 55 % for meats, and 60 % for seafood in Japan. Although completely self-sufficient in rice, the staple food of its people, Japan relied almost entirely on imports for the supply of wheat and beans (MAFF). The principal cause for the drop in the food self-sufficiency rate is the decline in domestic production capacity due to a decrease in the number of workers engaged in agriculture, as well as the change of the Japanese people’s diet, a lower consumption of rice and more meat products (Statistics Bureau, 2016). Thus, farmers in Japan should address FLA and promote the cultivation of abandoned farmland while food shortages in the developing world require more effective use of agricultural resources overall (JFIR, 2009). In addition to knowing the process of FLA, how to revitalize abandoned farmland should also be taken into account. Moreover, there still remains a large number of small-scale and less-commercial farm households in Japan. For a country with such a large population and economic significance worldwide, Japan has been experiencing a consistent downward trend for food security during the past 50 years (Hisano et al., 2018). This development hinders the social and cultural development of rural areas which may cause a great threat to national food security.

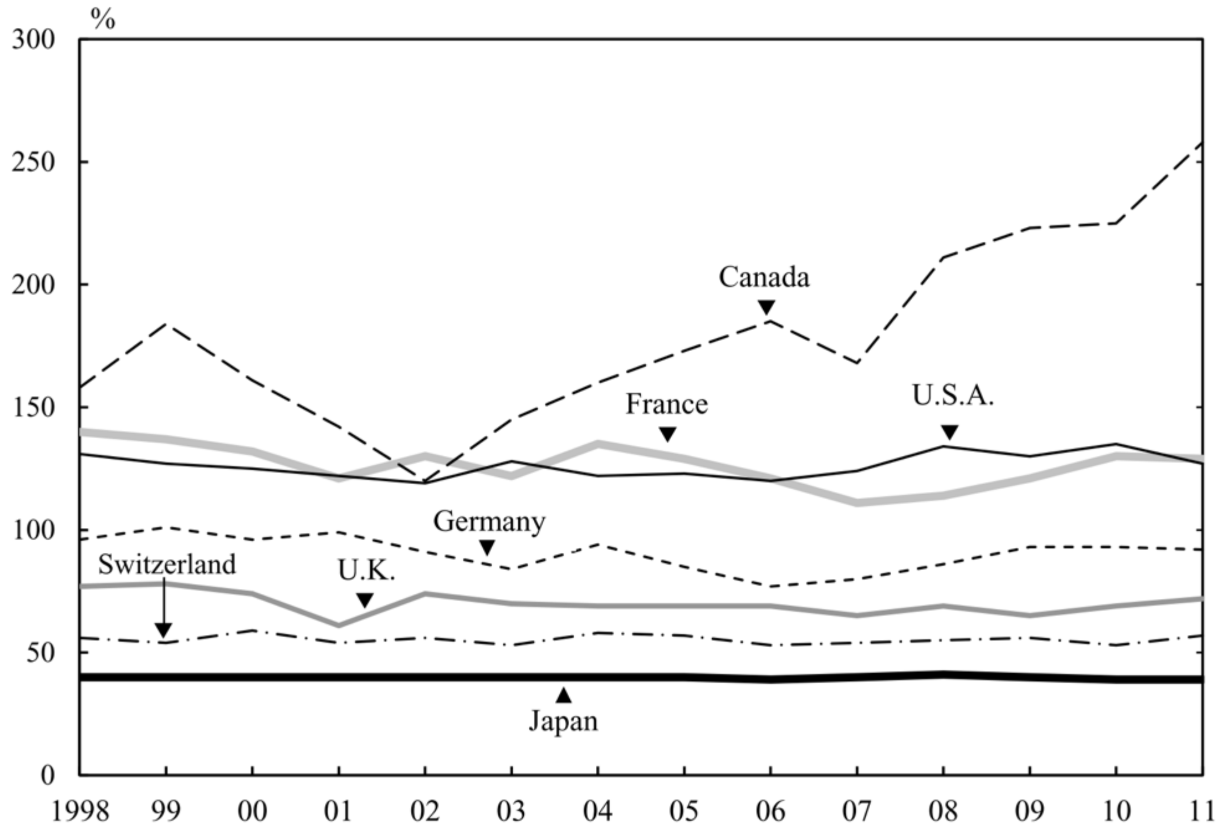


Figure 1-1 Trends in food self-sufficiency rates of major OECD countries

Source: ***Ministry of Agriculture, Forestry and Fishery*** *(MAFF), 2015.*

Another factor for the FLA that needs to be considered is the aging issue. The aging of farmers in Japan exhibits a negative future for the maintaining and development of agriculture. In Japan, the ratio of population aged 65 and older ranks the highest level compared with most of other countries. As Figure 1-2 depicts, the period when the percentage of persons aged 65 and older exceeded 10 % in Japan was earlier than the U.S.A. and most European countries. In 2015, the percentage of the population 65 and older in Japan was 26.6 %, exceeding the USA and most European countries, indicating that the aging society in Japan is progressing rapidly (Figure 1-2). Farmers age pyramid (Figure 1-3) also displays that the age structure of and most farmers are aged over 60 years old. Male farmers are dominant in agricultural laborers; however, they take a higher ratio of aging than female farmers, and the most farmers are aged 65 to 69 years. Due to the aging of farmers, many rural areas in Japan lack enough labor to manage agriculture in addition to the lack of successors. All these factors lead to the shrinkage of agriculture.

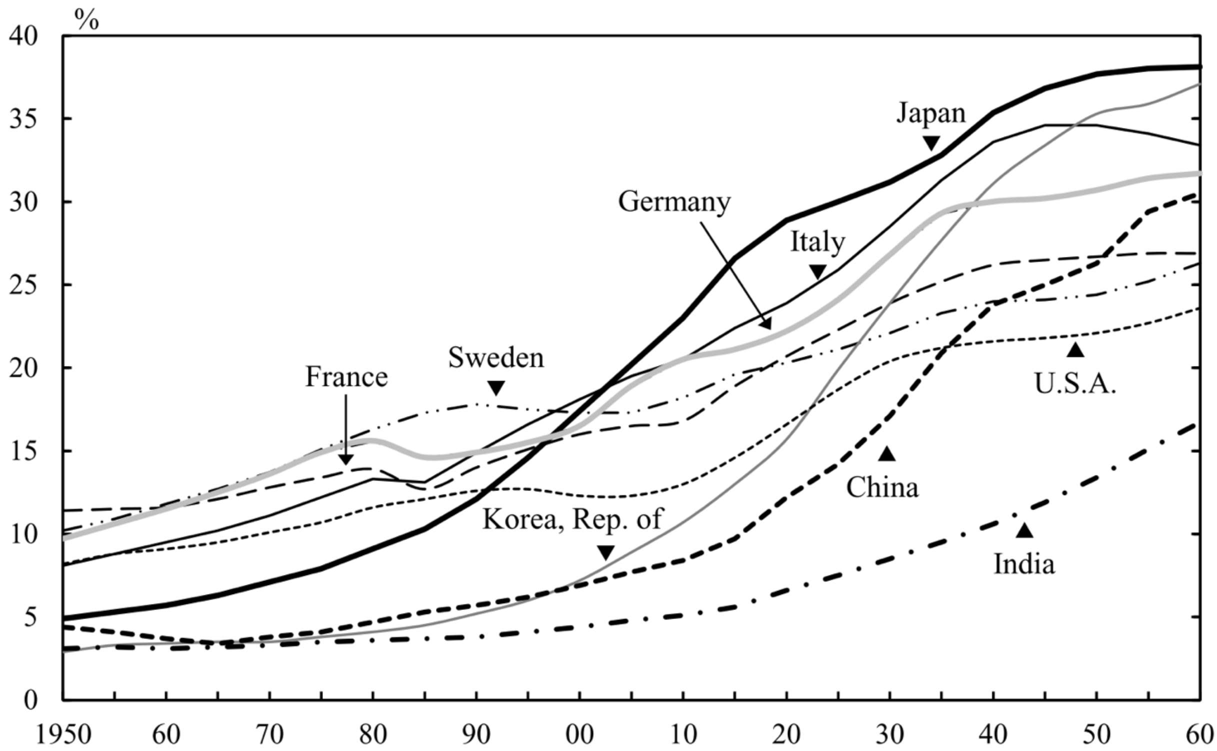


Figure 1-2 Proportion of elderly population by country (Aged 65 and older)

Source: *MAFF, 2015.*

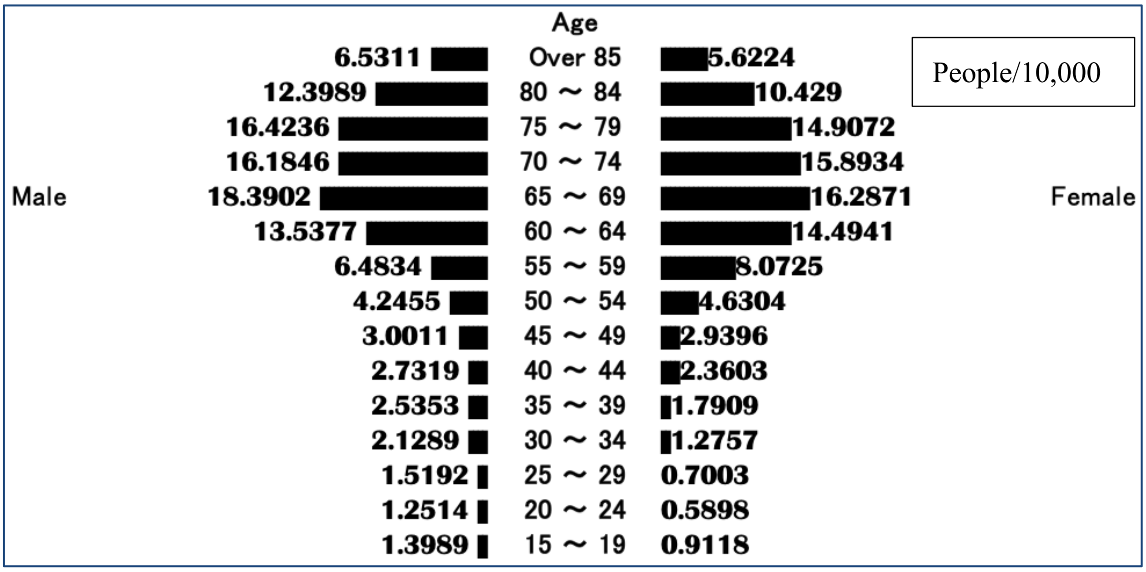


Figure 1-3 Population pyramid of Japanese farmers who engage in agriculture (By business farm households)

Source: *MAFF, 2015.*

1.1.1 Farmland transition processes in postwar Japan

Land reform after World War II and the Agricultural Land Act (ALA) enacted in 1952, laid the foundation of the Japanese farmland system (Ito et al., 2016). ALA argued that farmland owners have the right and priority to manage their farmland and this ownership has been restricted only to farming households (McDonald, 1997). As a result, with the rapid economic growth that started in the late 1950s, the principle of owner-cultivators was confronted with serious economic contradictions related to the small size of individual farms. Initially, the agricultural sector in postwar Japan was strictly noncorporate. This regime, however, has been shifting gradually but substantially over the past 25 years. During that process, the promotion of consolidating and deregulating of farmland is at the heart (Jentzsch, 2017). In Japan, the decline of agriculture was largely influenced by agricultural production, which is weakening with less farmland and fewer farmers (Hori, 2012). Due to this trend, small scale farm households need to spend more effort on managing their farmland and cannot compete with big scale farmers in the agricultural market. Many previous evidences also reveal that the small scale of farmland will contribute to FLA in most regions. Until today, not only individual farmers, but also community-based farm cooperatives (CBFCs) and companies started to engage in agriculture and contribute to the revitalization of farmland. In this regard, the author not only focus on individual farm households but also community-based farming in Japan to examine the determinants of FLA.

1.1.2 Historical background: historical FLA research

FLA is not a new phenomenon in many developed and developing countries. Research regarding FLA was initially conducted in many European countries which reflect a post war trend of rural depopulation to which isolated and poorer areas are most vulnerable (MacDonald et al., 2000). Between 1990 and 2006, "a total area of about 54 920 ha was abandoned in Western Europe whereas in Eastern Europe an area of about 67 960 ha was abandoned (Ustaoglu & Collier, 2018). Since 2000, many scholars started to pay much attention to FLA and its drivers in developed countries in Europe, and North America (Kolecka et al., 2017; Prishchepov et al., 2013; Ramankutty et al., 2010; Vinogradovs et al., 2018a), and gradually expanded research to some developing countries in Asia (Löw, et al., 2015; Yamaguchi et al., 2016) and Latin America (Díaz et al., 2011; Xu et al., 2019). In Japan, FLA has been investigated from the early 1990s by many local scale investigations. However, this phenomenon remains ill-understood in East Asia, particularly in heavily depopulated countries, such as Japan. As such, this research mainly focuses on Japan and tries to fill this gap by revealing the mechanism of FLA at multiple scales.

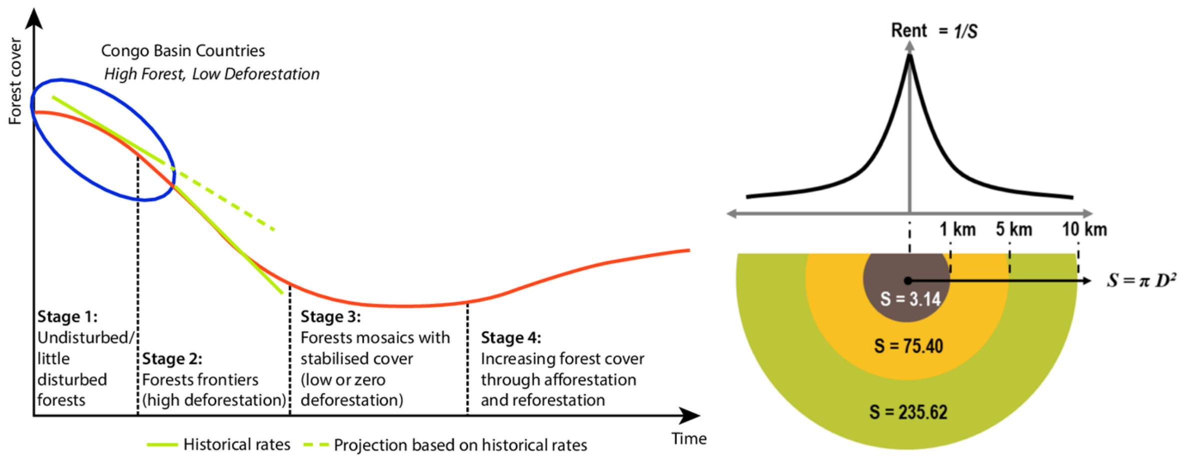
FLA studies that focuses on geographical contexts have greatly diversified over the past few decades. Mountainous areas have firstly experienced the trend of FLA which then spread to suburban and plain areas (Sanz et al., 2013; Zhang et al., 2014; Haddaway et al., 2014; van der Zanden et al., 2018). In mountainous areas, the agricultural activities have always been restricted by unfavorable conditions such as geographical situation and accessibility (van der Zanden et al., 2017). In suburban or plain areas, the driving forces of FLA were more complicated. During the process of urbanization, much marginal farmland were turned into urban uses (Zambon et al., 2018). In the plain area, the land consolidation is necessary for conservation of prime farmland, and also establishment of contract farming is indispensable to cover labor shortage (T. Takahashi, 1997). Such results also provided some evidences for dividing the region and scales of FLA into different contexts.

1.1.3 Theoretical background: theories relate to FLA and farmland management

Mather's Forest Transition Theory (Mather, 1992; Mather & Needle, 1998) and Von Thünen's Bid Rent Theory (Land Rent Theory) (von Thünen & Hall, 1966) are the two most important theories for explaining FLA and the change of farmland. Forest Transition Theory (Figure 1-6(a)) outlines the change from shrinking to expanding of forests that results from economic development and industrialization. There are four stages of forest regeneration from shrinkage: Stage one describes undisturbed or very little disturbed forests, which indicates the effects of economic development and industrialization are still weak. Stage two states the forests frontiers (high deforestation) which means after high economic period, forests have a lowest level. Stage three is forests mosaics with stabilized cover and there was low or zero deforestation. Stage four stands for increasing forest cover through afforestation and reforestation.

Bid Rent theory (Figure 1-6(b)) states that landowners are profit maximizers, allocating their land to the use of yielding the highest rent. Therefore, the distance of a land parcel to markets (Von Thünen ideas) and the 'quality' of land, in terms of geophysical characteristics (Ricardian ideas), determine the land-use decision of each landowner.

The Forest Transition Theory and the Bid Rent Theory were employed to explain FLA process. On the one hand, Forest Transition Theory poses that due to economic development and industrialization, agricultural intensification will be concentrated in the most suitable regions and it will become unprofitable in marginal fields, which will become abandoned and left to forest regeneration. Most scholars have motioned that in developed countries, forest transition is achieved by means of an "economic growth pathway," while the forest transition in developing countries occurs by following a "forest scarcity pathway" (Rudel et al., 2010). Economic growth pathway describes economic development that creates enough non-farm jobs, which allow farmers to give up doing agriculture, thereby abandoning poor farmland and contributing to reforestation (Rudel et al., 2005; Oldekop et al., 2018). Therefore, most scholars insist that abandoned farmland which is near mountains or will cost more to be re-cultivated should be transferred into forests that can generate more ecological values such as increasing habitat availability and connectivity for forest-dwelling species (Kuemmerle et al., 2008; Rautiainen et al., 2016). On the other hand, according to Bid Rent Theory, landowner are profit maximizers. Thus, farmers who owning farmland also pursuit for the biggest profit from agriculture. When they make the decision to abandon their farmland or not, most variables that will affect the yields of farmland will be considered. Where the natural features of the farmland, such as climate, soil, topography, and other factors remain constant, the location of agricultural production was determined by the farmers after balancing accessibility or cost and benefit (Sroka et al., 2018).



(a) (b)

Figure 1-4 The diagrams of (a) Forest Transition Theory and (b) Bid Rent Theory

Source: *The Geography of Transport Systems FOURTH EDITION & Deforestation Trends in the Congo Basin: Reconciling Economic Growth and Forest Protection.*

For the three scales considered in this study, the selection of the explanatory variables is largely based on the Forest Transition Theory and the Bid Rent Theory. Those two theories also assist to explain the processes and future management of FLA and farmland (Figure 1-7). FLA in Japan is primarily due to the weakening of rural areas and urbanization. The Forest Transition Theory clearly demonstrated the transfer between forest land and farmland during the process of higher economic growth. While the Bid Rent Theory explicitly stated the transfer between farmland and human uses. Landowners or farmers are profit maximizers and can decide the utilization or abandonment of farmland. As a result, marginal or periphery farmland are more prone to be abandoned.

From the national scale: the author considered environmental and socio-economic variables which were mainly based on socio-economic situations of farmers or farm households (Prishchepov et al., 2013; Gellrich et al., 2007). Such explanatory variables considered the two theories and help to explain the process of FLA at the national scale. Bid rent theory supports the selection of most geographical and socio-economic variables such as topographical condition, accessibility, and farm household situations which might influence the yield. Different stages of FLA from national scale can be interpreted by forestry transition theory.

From the intraregional scales: intraregional land use change is the outcome of many small-scale drivers and changes, as such, the extent and impacts of change may be highly variable across even relatively small region (Williams & Schirmer, 2012). Intraregional agricultural characteristics are employed as explanatory variables to explain FLA.

From the local scale: Individual farm households and community-based farm cooperatives were selected to know their awareness of FLA and to discuss the future development of FLA. The bid rent theory can be employed to explain farmers' preference of making abandonment decisions. Results also suggest a bottom-up approach for agriculture development. For the future development of FLA, forest transition theory might be helpful in interpreting ecological values of farmland.

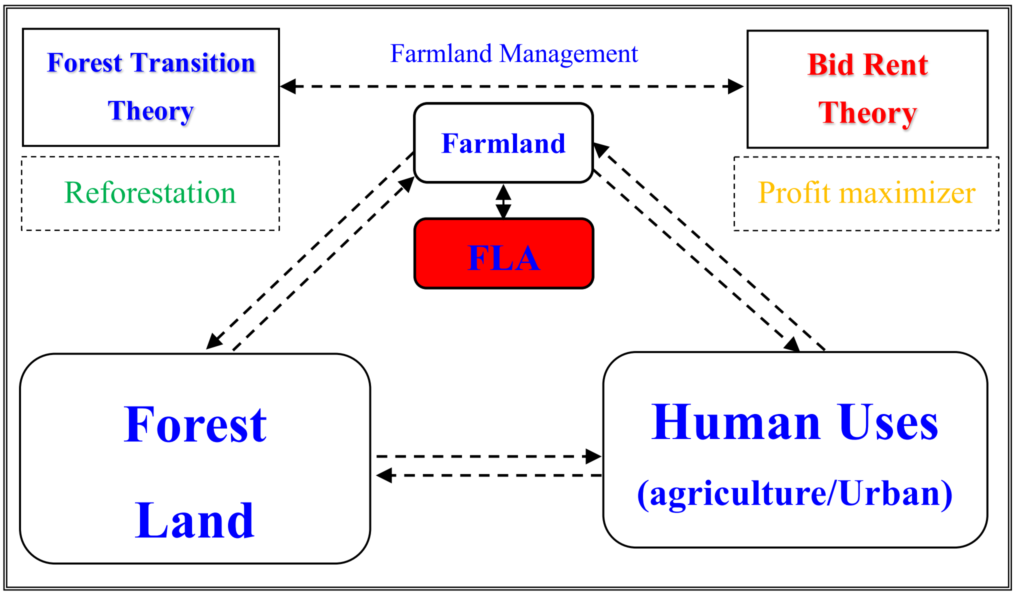


Figure 1-5 Theoretical framework of the research

1.2Literature Review

This part reviews the literature regarding definition of FLA, its drivers or determinants, agriculture and FLA, and finally future countermeasures. The summary of previous studies follows the questions of what FLA is, why FLA happened, and how to deal with FLA procedures to address the research gaps and to design the research. Different from research background, this part mainly examines the existing literature in different region and the research progress through more detailed results relating to this study.

1.2.1 Conception and measurement of FLA

FLA, also known as agricultural abandonment (MacDonald et al., 2000; Kuemmerle et al., 2008; Ramankutty et al., 2010; Osawa et al., 2016; Levers et al., 2018), cropland abandonment (Deininger et al., 2012; Zhang et al., 2014; Meyfroidt et al., 2016), or idle farmland (Morimoto, 1993) can generally be described as the cessation of agricultural activities on farmlands, which subsequently leads to undesirable changes in biodiversity (Beilin et al., 2014; Kamp et al., 2018) and ecosystem (Corbelle-Rico et al., 2014; Terres et al., 2015; Levers et al., 2018; Novara et al., 2017). As FLA can be a complex and gradual process, scholars usually categorize FLA into two types with different abandonment degrees: total abandonment or complete abandonment and semi-abandonment or partial abandonment. Total abandonment is defined as complete cessation of any agriculture activity on farmland and without other activities such as urbanization or afforestation (P. Pointereau et al., 2008; Janus & Bozek, 2019). Semi-abandonment refers to farmland that was not used for agricultural production but remains regularly managed, for example, through cutting grass or shrubs that were left on the farmland (Vinogradovs et al., 2018). Such farmland is not formally abandoned and is subjected to some potential utilization, which might transfer into future uses, for instance, for tourism activities (Keenleyside et al., 2010). In addition, there might be transitions among farmlands such as from abandoned farmland to forest land or other land and semi-abandonment to total abandonment over time and space driven by a different set of determinants (Munroe et al., 2013; Yang et al., 2019). This study considers FLA as total abandonment which exhibited no signs of future uses.

FLA is usually dynamic and difficult to measure as its conceptual definition changes over space and time, and a different focus of study can yield very distinct results (Rudel et al., 2005; Terres et al., 2015). According to existing studies, developed countries, such as the United States (Ramankutty et al., 2010), Australia (Williams & Schirmer, 2012), Japan (Osawa et al., 2016), and some European nations (Plieninger et al., 2016; T. Lasanta et al., 2017; Ustaoglu & Collier, 2018) particularly in Central and Eastern Europe (Janus & Bozek, 2019), share the greatest dispersion of FLA acres across the relevant territory. In most developed countries, FLA was first observed in the 1990s in Europe (Kuemmerle et al., 2008; Ustaoglu & Collier, 2018), and more abandonment in terms of area took place in the early 21 century (T. Lasanta et al., 2015). Scholars have focused on FLA for a long time and try to find better solutions toward this issue. Recent scholarship puts more emphasis on FLA in developing countries, where people rely more heavily on agriculture for their livelihoods (Löw et al., 2015; Zhang et al., 2016; Li & Li, 2016; Yamaguchi et al., 2016; Xu et al., 2019b). For the measurement of FLA, previous studies have chiefly focused on its spatial characteristics (Sluiter and De Jong, 2007), driving forces or determinants (Prishchepov et al., 2013; Levers et al., 2018), countermeasures (Ito et al., 2016), and future prospects (van der Zanden et al., 2018). In terms of causes or drivers of FLA, most studies have been conducted with a focus on environmental or ecological (Ustaoglu and Collier, 2018) and socio-economic aspects (Gellrich and Zimmermann, 2007; Yamaguchi et al., 2016), and these studies have considered linear (Sang et al., 2014) and non-linear (Levers et al., 2018) relationships. Thus, previous studies mostly focused on individual factors to interpret FLA drivers by local regressions. Such results allow researchers to quickly understand the driving factors of FLA in a particular region. However, major problems could occur when independent variables are highly correlated (Tan et al. 2016). Hence, approaches or methodologies that not only considers individual factors, but also takes into account a full set of variables eliminated from such multicollinearity allow us to identify new perspectives to explain the causes of FLA.

1.2.2 Different regions and FLA

FLA is usually driven by multiple factors, and the setting of proper time spans and scales for study can be expected to influence its determinants significantly (Yamaguchi et al., 2016; Pazúr et al., 2014; Rudel et al., 2005). Empirical studies have shed light on spatial patterns of FLA and its drivers in Europe at different times and scales (Larsson & Nilsson, 2005; Foucher et al., 2019). In terms of spatial patterns, remote sensing (RS) is widely used to capture and monitor FLA variations (Estel et al., 2015; Juraj et al., 2015; Löw et al., 2018; M. et al., 2019). This technology allows researchers to identify spatial patterns, as well as areas with low and high abandonment rates quickly and precisely. Table 1-3 depicts previous studies in different scales and determinants of FLA. FLA varies among different geographical conditions and has drawn much attention in many countries.

The studies on FLA are normally divided into three scales: national, regional, and local (parcel or community) scales. Europe has the most studies regarding FLA, which are usually conducted at macro-scales such as national and regional. In American and Asia, scholars also focused on FLA at multiple scales, and a mixed sampling methodology has been chiefly employed. In Japan, local or community scale studies are more popular, and most scholars conducted household surveys to know the specific situation of FLA.

However, many researchers have found that FLA is a complex multi-dimensional process, interlinked with regional environmental, economic and social conditions (Zakkak et al., 2015; Prishchepov et al., 2013; Mottet et al., 2006; Baumann et al., 2011; Müller et al., 2013; Liu et al., 2015). Drivers of abandonment are spatially diverse and are difficult to monitor due to the challenging regional or local circumstances (Terres et al., 2015). This diversity is reflected not only in the spatial identification of abandonment but also in the regional variations in the characteristics of socio-economic development and land use (MacDonald et al., 2000). Determinants are often examined at pixel, village or household levels (Prishchepov et al., 2013; Müller et al., 2013; Zhang et al., 2014). Such information supports regional planners and policy-makers to implement effective countermeasures, such as controlling possible environmental impacts of land abandonment or preventing its expansion by issuing new laws and regulations (Löw et al., 2015; Sanget al., 2014)

In the case of Japan, most scholars insist that FLA has both positive and negative impacts on the environment, but primarily negative socio-economic consequences for agriculture and food security. In response, the Japanese government updated its law for sustainable agricultural practices to the Basic Law on Food, Agriculture and Rural Areas, which started to be enforced in 1999. This law was necessary in order to promote agricultural production that remains in harmony with the environment without compromising food security, thereby leading to the healthy development of agriculture. Overall, FLA remains ill-understood in East Asia. As such, this research mainly focuses on Japan and tries to reveal the mechanism of FLA in national, regional and local contexts. Such results follow: FLA and farmland use changes—determinants and mechanisms—consequences—countermeasures and policy implications, which provides rich information of FLA under different geographical and socio-economic circumstances.

Table 1-1. Different studies of FLA and its driving forces

Contents (Title)	Region	Author	Scale	Driving Factors of FLA
Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response.	Western Europe Mountain zones	(MacDonald et al., 2000)	National	Environmental, agricultural and socio-economic contextual factors
Land abandonment, biodiversity and the CAP	the New Member States and Candidate Countries	(European & Affairs, 2004)	Regional, cross national	Land reform and structural change, socio-economic factors, declining viability of agriculture, national EU policy
Vegetation composition and succession of abandoned farmland: effects of ecological, historical and spatial factors.	North America Québec (Canada)	(Benjamin & Domon, 2005)	National	Ecological variables: slope, surface stoniness, canopy opening, soil pH, land-use history, age of the abandoned farmlands
Agricultural land abandonment and natural forest re-growth in the Swiss mountains: A spatially explicit economic analysis	The Swiss mountains	(Gellrich et al., 2007)	Regional	Poor water availability, small-scaled topographic peculiarities, and the individual's motivation
Investigating the regional-scale pattern of agricultural land abandonment in the Swiss mountains: A spatial statistical modelling approach	The Swiss mountains	(Gellrich & Zimmermann, 2007)	Regional	Shallow soils, steep slopes, under-developed road infrastructure, low proportions of full-time farms
Spatial patterns of Mediterranean land abandonment and related land cover transitions	Mediterranean France	(Sluiter & De Jong, 2007)	Regional	Environmental factors: distance to roads and urban areas, wetness index, potential radiation, elevation, slope, soil class
Cross-border Comparison of Post- socialist Farmland Abandonment in the Carpathians	Eastern Europe	(Kuemmerle et al., 2008)	National	Differences in socialist land ownership patterns, post-socialist land reform strategies, and rural population density
Combining top-down and bottom-up dynamics in land use modeling: Exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model	Europe	(Verburg & Overmars, 2009)	Regional	Macro-economic conditions and the characteristics of the location.
Prevailing Myths About Agricultural Abandonment and Forest Regrowth in the United States	the United States	(Ramankutty et al., 2010)	National	Agriculture structures, forest transition
Farmland Abandonment in the EU: An Assessment of Trends and Prospects	EU	(Keenleyside et al., 2010)	Regional	Agricultural intensification and marginalization, accessibility, population change, small farms
Hydrological and erosive consequences of farmland abandonment in Europe, with special reference to the Mediterranean region	Parts of Europe	(García-Ruiz & Lana-Renault, 2011)	Regional	Depopulation, the use of modern agricultural machines, steep slope, climatic conditions

Patterns and drivers of post-socialist farmland abandonment in Western Ukraine	Western Ukraine	(Baumann et al., 2011)	National	Eastern: Topography, soil type, and population variables Western: Urbanization and industrialization
Drivers of land abandonment in Southern Chile and implications for landscape planning	Southern Chile	(Díaz et al., 2011)	National	Distances to secondary roads and parks, farm subsidies. Farm structural variables (bovine heads, livestock carrying capacity).
Multi-scale assessment and spatial modelling of agricultural land abandonment in a European peripheral region: Galicia (Spain)	Europe (Galicia, Spain)	(E. Corbelle-Rico et al., 2012)	Parcel	Biophysical limitations, slope, accessibility
Modelling farmland abandonment: A study combining GIS and data mining techniques	Spanish Mediterranean	(Zaragozí et al., 2012)	Regional	Plot area, irrigation, vegetation index, topographic wetness index, structural variables, climatic index
Comparing the determinants of cropland abandonment in Albania and Romania using boosted regression trees	Central and Eastern Europe	(Müller et al., 2013)	National	Elevation, slope, market access,
Determinants of agricultural land abandonment in post-Soviet European Russia	Post-Soviet Russia	(A. A. Prishchepov et al., 2013)	National	Low grain yields, political legacies (subsidies, markets)
Long-term forest dynamics and land-use abandonment in the Mediterranean Mountains, Corsica, France	Mediterranean Mountains	(Sanz et al., 2013)	Regional	Suspension of human influence, interruption of traditional farming practices
The perception of abandoned farmland by local people and experts: Landscape value and perspectives on future land use	Latvia	(Ruskule et al., 2013)	National	People's perception: inefficient use and desolation
Determinants of cropland abandonment at the parcel, household and village levels in mountain areas of China: A multi-level analysis	China	(Zhang et al., 2014)	Provincial Multi-scales	Slope, soil quality, remoteness, agriculture laborer, elevation, low prevalence of leased land
Regionality in Norwegian farmland abandonment: Inferences from production data	Norway	(Sang et al., 2014)	National	Agricultural subsidies, farming system
Spatial determinants of abandonment of large-scale arable lands and managed grasslands in Slovakia	Slovakia	(Pazúr et al., 2014)	National	Soil quality, accessibility, migration, population structure, topographic condition
Exploring the Dynamic Mechanisms of Farmland Abandonment Based on a Spatially Explicit Economic Model for Environmental Sustainability	China	(Xie et al., 2014)	Provincial	Remoteness, costs of cultivation, crop yield
Farmland abandonment in Europe: Identification of drivers and indicators, and development of a composite indicator of risk	27 EU Member States	(Terres et al., 2015)	Regional	Low incomes, ageing population, lack of successors and strong environmental constraints
The abandonment of traditional agricultural landscape in Slovakia - Analysis of extent and driving forces	Slovakia	(Lieskovský et al., 2015)	National	Steep slopes, less fertile soils, distance from settlements, financial profit

Changes in landscape fire-hazard during the second half of the 20th century: Agriculture abandonment and the changing role of driving factors	Mediterranean countries of southern Europe	(Viedma et al., 2015)	Regional	First abandonment: small farms, in distant locations, in municipalities with low population Later abandonment: large farms, soil condition, closer to towns, employment.
Community-scale analysis of the farmland abandonment occurrence process in the mountain region of Ladakh, India	Ladakh, India	(Yamaguchi et al., 2016)	Community	Altitudinal location, farm management (smaller field size, lower yields) and socio-economic conditions (high un- employment, negative migration balance)
Drivers of cropland abandonment in mountainous areas: A household decision model on farming scale in Southwest China	Southwest China	(Yan et al., 2016)	Regional, household	Off-farm wage, urbanization and industrialization
Land cover change on the Isthmus of Karelia 1939-2005: Agricultural abandonment and natural succession	North-West Russia	(Rautiainen et al., 2016)	National	The collapse of the Soviet Union
Problems and Solutions for Abandonment of Utilized Agricultural Areas in Latvia	Latvia	(Arika & Mazure, 2017)	National	Inefficient land management, lack the financial resources, time and willingness to manage the farmland.
Understanding farmland abandonment in the Polish Carpathians	Polish, Carpathians	(Kolecka et al., 2017)	National	Topography (mainly slope gradients) and employment outside of agriculture
Trade-offs of European agricultural abandonment	European scale	(van der Zanden et al., 2017)	Regional	location and scale
Farmland Abandonment in Europe: An Overview of Drivers, Consequences and Assessment of the Sustainability Implications	EU	(Ustaoglu & Collier, 2018)	Regional	Climate, soil, income, market, farm income, farmers' characteristics, farm structure, policies
Spatial variation in determinants of agricultural land abandonment in Europe	EU	(Levers et al., 2018)	Regional	Climate conditions,
Abandonment landscapes: user attitudes, alternative futures and land management in Castro Laboreiro, Portugal	Portugal	(van der Zanden et al., 2018)	National	Less productive, remote and mountainous areas with unfavorable conditions for agriculture
Agricultural abandonment and re-cultivation during and after the Chechen Wars in the northern Caucasus	Caucasus	(Yin et al., 2019)	Regional	Closer to armed conflicts
Drivers of land abandonment in the Irish uplands: A case study	SW Ireland	(O'Rourke, 2019)	Local, community	Low incomes, ageing population, lack of successors and strong environmental constraints
Multiple factors drive regional agricultural abandonment	Japan	(Osawa et al., 2016)	National, mesh	Effectiveness of cultivation, climate factors, numbers of potential farmers

The contribution of land exchange institutions and markets in countering farmland abandonment in Japan	Japan	(Ito et al., 2016)	National, prefectural	Land-holding non-farm households,
The increase of fallow and abandoned cultivated land with the development of intensive agriculture	Japan	(Morimoto, 1991)	Local	Labor shortage in intensive vegetable cultivation
Idle and abandoned farmland in Kashiwai-cho 4-chome, Ichikawa City, Chiba Prefecture	Japan	(Morimoto, 1993)	Local	Part-time farming, prohibition of farmland use, paddy field condition, farmland price, rental
Analysis of Characteristics of Abandoned Farmland and Preventive Measures in Urbanized Farming Communities	Japan	(T. Takahashi, 1997)	Local, community	Orange orchard, small scale, successors, self-sufficient
Utilization of Abandoned Cultivated Lands for Grazing (in Japanese)	Japan	(Koyama, 2004)	Regional	Utilizing abandoned farmlands as pastures for grazing cattle
Measurement Analysis of the Cultivated Acreage and Abandoned Cultivated Lands (in Japanese)	Japan	(Inaba, 2006)	Local, Prefecture	Slope, labor condition of farm household, management
Livestock Production by Integrated Grazing System for Scattered Small Pastures in Eastern Japan (in Japanese)	Japan	(Shindo & Tejima, 2006)	Regional	Utilizing abandoned farmlands for animal husbandry
Expansion of Abandoned Cultivated Land and Related Factors in a Marginal Hamlet in Minamata	Japan	(Teratoko, 2009)	Local	Retirement of farmers, agricultural machines, leasing of farmland, for special use
Abandonment and intensified use of agricultural land decrease habitats of rare herbs in semi-natural grasslands	Japan	(Uematsu et al., 2010)	Local	Elevation, slope, far away from roads,
Evaluation of Social Factors and Geographic Factors that Affect the Distribution of Cultivation Abandonment Land	Japan	(Nakae & Morita, 2013)	Local, prefectural	Inclination angle, elevation, management
Prevention Mechanism of Farmland Abandonment in a Mountain Village in Nishi-Aizu Town	Japan	(Shoji, 2015)	Local	Low profit of agriculture, decrease of labor
Influence of Abandoned Farmland and Protection Fence on Agglomeration and Connectivity of Wild Boar Habitat around Orchard Field	Japan	(Takeyama et al., 2015)	Local, regional	Influence of wild boars
Econometric Analysis of Farming Land Abandonment in the Tohoku Region Using Community Level Data	Japan	(Kawashima & Kano, 2016)	Regional	Location and steepness of farming

1.2.3 Agriculture and FLA

Understanding the relationship between agriculture and farmers is the key to understanding FLA problems because different socio-economic situations of farmers or characteristics of agriculture will affect abandonment differently. Indeed, agricultural management varies from region to region, as a consequence of natural conditions, historical traditions, and socio-economic or demographic contexts (Smaliychuk et al., 2016). On the one hand, agricultural characteristics influence FLA mainly in its scale (Cocca et al., 2012). For instance, Japanese agriculture is characterized by small farm sizes (Hisano et al., 2018) and is often located in hilly and mountainous areas (HMAs), which make up around 70% of the national territory (Ministry of Agriculture, Forestry and Fishery, (MAFF), 2015). Such farmland is extremely unfavorable, as it requires higher labor and economic costs for cultivation and can easily turn into abandoned farmland. Proper scale-setting for farming (Yamaguchi et al., 2016) and adjustment of fragmented farmland (Arimoto, 2010) have been shown to act as an effective countermeasure against FLA.

On the other hand, FLA affects the remaining agriculture in that, as one farm is abandoned, adjacent farmland will become more challenging to cultivate because of changes in geographical and biological conditions (MacDonald et al., 2000). In addition, FLA and the subsequent restoration of vegetation will significantly change rural land use patterns, landscapes, and farmers' livelihoods (Li and Li, 2017). As a consequence, FLA needs to be analyzed with due consideration of agricultural characteristics in a given region to support better agricultural management.

The relationship between agricultural characteristics and FLA has been partially documented. Generally, agricultural intensification or expansion is linked to urbanization, which is often associated with FLA and a decline of land-use intensity in peripheral regions (Plieninger et al., 2016). Typically, owners of abandoned farmland are heirs to their ancestors' farmland who have migrated to urban areas for employment and do not intend to cultivate the inherited farmland. Besides, the structure, type, and socio-economic situation of farm households will affect agricultural strategies of farm households. An unfavorable socio-economic situation of farm households can further lead to FLA (Ito et al., 2016; Su et al., 2018), as the abandonment of farmland is basically decided by individual farm households (Zhang et al., 2014). Moreover, regional agricultural practices regarding farmland can also have a strong impact on FLA prevention. Because the location and scale of the farmland predict FLA outcomes, such information can be used in developing targeted measures for areas that face similar management challenges (van der Zanden et al., 2017). Planning and policy that aim at either preventing FLA or managing abandonment should consider social and environmental challenges (van der Zanden et al., 2018). Setting taxes at appropriate levels can encourage farmers to sell or lease their abandoned farmland and aid in its transition (Nishihara, 2012). Abandoned farmland can also be considered for future use, such as renewable energy production (Abolina and Luzadis, 2014). Although the general weakening of agriculture is found to cause FLA, the impacts of problems in specific domains of agriculture and regional agricultural characteristics on FLA are still largely unknown. This study aims to address this gap by conducting intraregional analysis in the Chugoku and Shikoku region as a case study. How intraregional agricultural characteristics affect FLA is elucidated.

1.2.4 Countermeasure and future of FLA

Most Japanese scholars insist that FLA has both positive and negative impacts on the environment, but primarily negative socio-economic consequences for agriculture and food security (Osawa et al., 2016; Ito et al., 2016; Yamashita & Hoshino, 2018). Relevant studies in Japan focus on FLA and its driving factors or countermeasures mainly at the national, local, or individual farm levels. The general relationship between FLA and environmental and socio-economic factors has been examined at national scale. Factors such as small size and low accessibility of farmland, slope (Lieskovský et al., 2015), and the aging of farmers are inaccessible to increase FLA (Osawa et al., 2013; Osawa et al., 2016; Su et al., 2018). Despite these difficulties, farmers have been trying to re-cultivate their abandoned farmland in recent years. Ito et al. (2016) analyze how land exchange institutions facilitate farmland use and reverse abandonment. On a local scale, many case studies examine the process and drivers of FLA by conducting field surveys and interviews. Farm household structures, labor conditions (Morimoto, 1991), successors (Kuki and Takahashi, 1997), and agricultural management strategies have been shown to be strongly correlated with FLA (Morimoto, 1993; Yukio, 2009; Shoji, 2015). Such localized results illustrate farmers' and farm households' perceptions of FLA in a developed country and how they vary across different spaces. However, few studies of FLA focus on the regional level and take into account specific intraregional agricultural characteristics, especially in western Japan. Hence, it is meaningful to clarify FLA in a regional context, to discuss intraregional agricultural characteristics, and to formulate better recommendations for farmland use.

Post abandonment studies also have great meaning for FLA prevention and farmland management. Renwick (2013) insisted that rather general agricultural policies which maintain farmland in production are likely to be ineffective and inefficient to address the perceived negative consequences of abandonment (Renwick et al., 2013). Thus, more detailed and localized information about agriculture should be provided. Sang (2014) pointed out that spatial data and technologies should be accessible to assist policy makers and should be used to provide insights into the local impacts of current policy (Sang et al., 2014). On one hand, attitudes towards abandoned farmland are rather negative, it being mainly associated with insufficient use and desolation over the world (Renwick et al., 2013). But on the other hand, the impacts of FLA are not unacceptable in all regions. Rey-Benayas et al. (2007) have discovered that abandonment of farmland may also benefit humans such as with more values from environment, biodiversity and wilderness (Rey Benayas et al., 2007). Whether it is good or not in different regions, experts should be much clearer and make evaluations regarding different situations, finally policy makers can manage the abandoned farmland more effectively.

1.3Research Aims and Scope

1.3.1 Research gaps

As stated before, most empirical studies have found that FLA has always occurred firstly in hilly and mountainous regions. In Japan, there are many HMAs distributed widely throughout the country, which are less accessible due to disadvantaged geographical condition. In these areas, agriculture is difficult to maintain, and the shortage of labor cannot be supplemented immediately due to the lack of agricultural successors, aging, and population outflow, among other socio-economic factors. These factors are the prerequisite for the existence of high FLAR, especially in rural mountain villages. On the other hand, Japan is one of the countries that is experiencing high depopulation and aging population. The effectiveness of cultivation in largely concentrated farmland and lack of young laborers in agriculture directly promote abandonment.

To date, most studies on FLA were conducted in Europe, which experienced the most severe situation of FLA in terms of areas and scale. More recent studies also put more emphasis on developing countries such as in Central Asia and South America. In the context of Japan, first, limited literature has evidenced FLA from a national scale. And most articles or materials have been published only in the Japanese language. Second, this study also focused on intraregional and local context in West Japan, an area that has received less attention in the past three decades. Third, this study is to the author's knowledge, the first to rigorously compare FLA processes with agricultural characteristics and try to find a future countermeasure for FLA.

1.3.2 Research questions

This study was conducted from national, regional, and local scales and research questions at each scale are as follows:

From the national scale:

(1) What are the temporal and spatial patterns of FLA in Japan and its variations?

(2) How, and to what extent, do geographical and socio-economic determinants affect FLA?

(3) What are the spatial variations and determinants of FLA and why are there such variations?

From the intraregional scale:

(1) What are the spatial variations and patterns of agricultural characteristics in the Chugoku and Shikoku region?

(2) What are the factors or causes of FLA when agricultural characteristics are considered as independent variables instead of individual factors?

(3) What are the relationships between agricultural characteristics and FLA?

From the local scale:

(1) What are the roles of individual farm households in managing abandoned farmland and maintaining agriculture in Japan?

(2) What are the roles of ICBFCs in managing FLA and maintaining local agriculture?

(3) What could be the promising countermeasures of FLA and how to manage future FLA?

1.3.3 Research objectives

This study focuses on national, regional, and local scales for the spatial patterns and regional variations of FLA in Japan, and then finally tries to reveal its mechanism. The major objectives are as follows:

From the national scale: assessing the current FLA in Japan and building a database of FLA nationally, try to explain the spatial and temporal characteristics, determinants, and regional variations of FLA, finally try to explore the mechanism of abandonment;

From the intraregional scale: exploring the intraregional agricultural characteristics of one region and relationships to FLA, offer a new perspective to explain the process of FLA;

From the local scale: trying to look for countermeasures of FLA from ICBFCs' and individual farm households' perspectives, implementing some policies or taxation reforms;

Enhancing the understanding of FLA, its regional differences, and prevention of FLA by making better farmland use suggestions.

1.4Research Framework

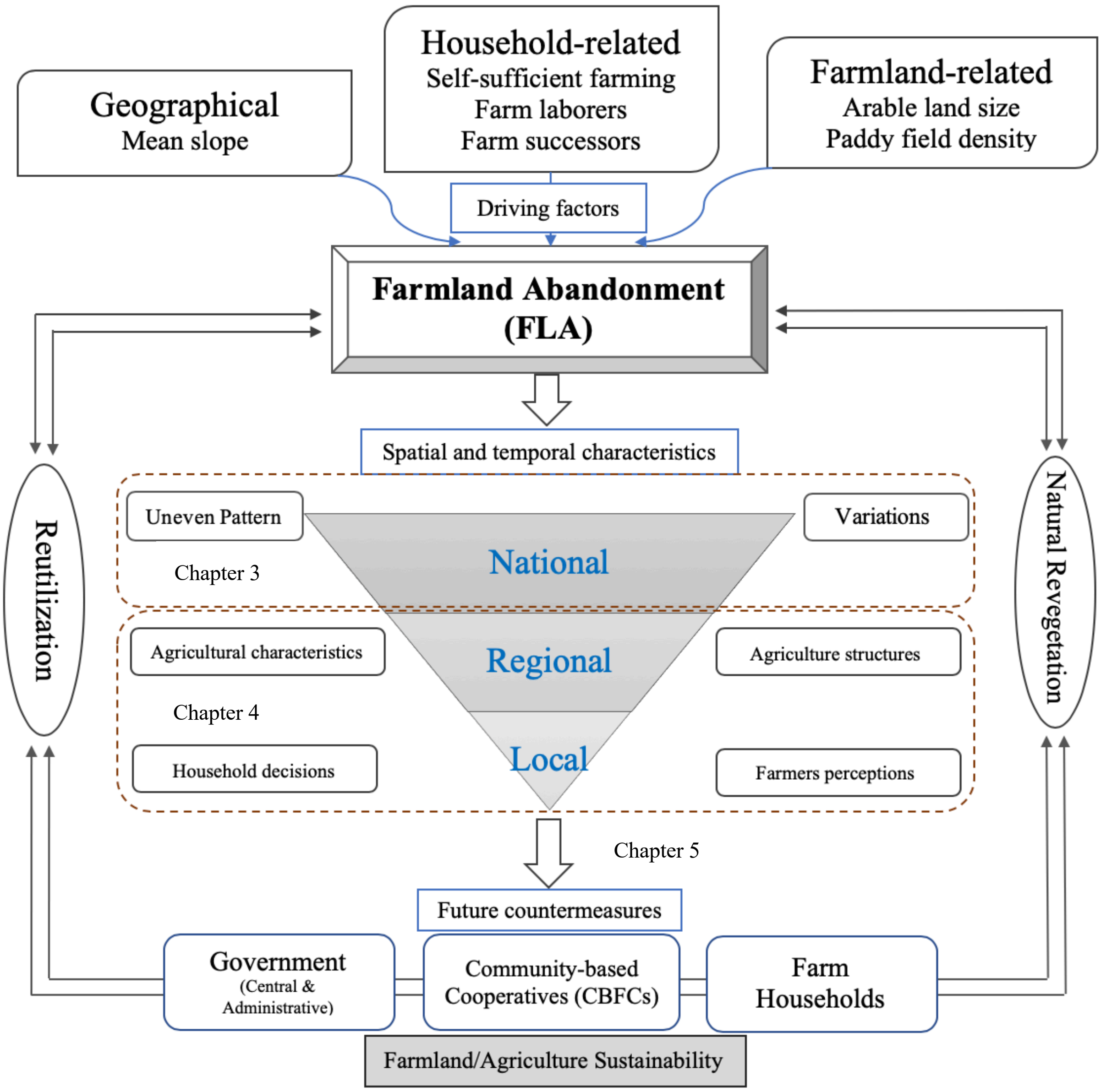


Figure 1-6 Conceptual framework of the research

In Table 1-3 in 1.2.2, we reviewed the previous literature regarding FLA in different countries. Results suggest the scale setting for the study of FLA normally divided into 3 categories which could provide different results from different angles. Therefore, in this study the author followed this rule and divided Japan into national, intraregional, and local scales respectively. As shown in Figure 1-8, the process of FLA, its driving forces, and future countermeasures are interlinked. FLA as a prevailing worldwide trend has been examined in the study. Bid rent theory and Forest transition theory were taken into consideration when dealing with variable selection and proposal of future management of abandonment.

First, from the national scale, chapter 3 focused on FLA from the national scale by considering the former municipalities. Thus far, there is no nation-wide studies, though it is clear from smaller studies that the causes and extent of abandonment are not the same across Japan and vary both temporally and spatially. For the driving forces or determinants of farmland, this study considers two aspects: geographical and socio-economic perspectives. For the geographical aspects, the mean slope mainly affects FLA in the region. For the socio-economic aspects, factors are divided into household-related and farmland related. All the factors exhibited significant positive or negative correlations to FLA.

Second, from intraregional and local levels, the analysis focused more on the detailed information to explain FLA. For example, on the intraregional scale, the intraregional agricultural characteristics or structures were selected as determinants to explain FLA, which could also evaluate agriculture development in different intraregional conditions.

On the local scale, the study explores the opinions of individual households and ICBFCs from the local level. Based on the survey result and analysis, the findings were concluded by making better agriculture management and farmland use suggestions considering government, ICBFCs, and individual farm households.

1.5Chapter outlines

This study focuses on national, intraregional, and local scales for the spatial patterns and regional variations of determinants regarding FLA in Japan, finally reveals its process, mechanism, driving forces, and effort to maintain agriculture and counter future abandonment.
Chapter 1 outlines a comprehensive introduction of FLA in Japan and worldwide, including studies in land use / land cover change and rural studies. A detailed literature review is included to illustrate the study on FLA in the world regarding different concepts, scales, methodologies, and driving factors. In the next section, research questions and objectives are discussed to raise the significance of this study. The final parts are the research framework and outlines.
Chapter 2 offers an explicit explanation of research data and methodology. Firstly, this chapter introduces the study area and the selection of research scales. Secondly, the research data is mentioned in regard to primary and secondary data sources (statistical data from the census of agriculture, forestry and fishery; survey data from a case study of Hiroshima Prefecture). Lastly, the research methodology in terms of the research framework and model design are introduced.
Chapter 3 on the one hand, reveals the spatial patterns of FLA from a national scale by employing former municipalities from 1950s. The results outline the spatial patterns and identify the clusters and low or high FLAR areas. On the other hand, the chapter explores how, and to what extent, geographical and socio-economic determinants affect abandonment by global and local regressions. These findings are essential for understanding the roles of selected variables in abandonment in East Asia and the differences from other nations and their spatial variations. This outcome generates a comprehensive understanding of abandonment associated with local geographical and socio-economic circumstances across study regions and, therefore, culminating in recommendations for future farmland use. This chapter is also a part of the published paper in 2018, details can be found in (Su at el., 2018).
Chapter 4 focuses on Chugoku and Shikoku region which experienced the highest FLAR and have a unique agriculture development by small scale farming. The chapter discusses the agriculture characteristics and FLA that fully take into account of each particular regional circumstance. Even though an increasing number of studies on FLA in other nations and Japan have been reported, limited studies have been conducted on the intraregional differences associated with agriculture dimensions over west Japan. Results offers a more detailed

explanation of FLA in intraregional scale which cannot be well explained from the national scale.

Chapter 5 focuses on the local level to explain FLA and its countermeasures by selecting Hiroshima Prefecture as a case study. Individual households and incorporated community-based farming cooperatives (In Japanese: *Syuraku Einou Houjin*) are targeted. Thus far, FLA and the function of community-based farming in countering abandonment and promoting agriculture development have not been well-understood. This chapter evaluates FLA at a local scale. Particularly, the roles of community-based farm cooperatives and individual farm households in preventing FLA are illustrated.

Chapter 6 discusses and concludes the main findings. Specifically, this chapter discusses FLA associated with local geographical and socio-economic circumstances across study regions. Some abandonment related policies have been reviewed, and recommendations for future farmland management are suggested. Japan’s case is a suitable empirical example for the supplemental understanding of FLA in general and for those who wish to thoroughly examine agriculture in a heavily depopulated society.

CHAPTER 2 RESEARCH DATA AND METHODOLOGY

This study is conducted from national, intraregional, and local scales to thoroughly examine the issue of FLA in Japan. Abandoned farmland normally refers to farmlands that have not been cultivated for one year and where there is no indication that it will be cultivated in subsequent years (MAFF, 2015). I take this definition and calculate a farmland abandonment rate (FLAR) to present and evaluate abandonment conditions, which can be expressed as:

$$FLAR = La/Lt \quad (1)$$

where $FLAR$ refers to the farmland abandonment rate, La presents the total abandoned farmland and Lt pertains to the total arable land.

Figure 2-1 (a-d) explicitly depicts the appearance of abandoned farmland in rural Japan, some general characteristics of FLA can be concluded: first, most abandoned farmlands have unfavorable accessibility. It can be noticed that most abandoned plots are near the mountainous areas and are far away from major roads, irrigation systems, and agricultural machines. Second, the abandoned farmlands are primarily located in unfavorable geographical conditions such as slope and high elevation areas. Third, the abandoned farmland tends to be small in their size and narrow shape, which constrains the cultivation. Due to the lack of management, they are all covered by grasses or shrubs.

(a)

(b)

(c)

(d)

Figure 2-1 Statues of abandoned farmlands in Japan (a-d)

Source: *author*.

2.1 Overview of Study Area

Japan is an island country located in the Pacific Ocean. It lies off the eastern coast of the Asian continent and stretches from the Sea of Okhotsk in the north to the East China Sea and the Philippine Sea in the south. It consists of four main islands: Honshu, Hokkaido, Kyushu and Shikoku, and many small islands. The Japanese archipelago lies between latitudes 24° and 46° N and longitudes 122° and 146°, with an area of 377,923.1 km2, of which mountainous areas occupy 73% of the total land area and only 12% of the land is suitable for cultivation. This region contains various kinds of landscapes, including flatland, HMAs, isolated island zones, etc. (Osawa et al. , 2016). Japanese territory is located in a tectonic plate movement zone with various physiographical phenomena. Therefore, the number of earthquakes and active volcanoes is relatively high (Ministry of Internal Affairs and Communications Japan, 2015). The main climate is a temperate marine climate, though the changes in the four seasons are distinct, depending on the effects of seasonal winds and ocean currents.

Japan is currently the third-largest national economy in the world, after the United States and China. The agricultural sector accounts for about 1.19% of the total country's GDP[1]. Japan's agricultural sector is highly subsidized and protected, with government regulations that favor small-scale cultivation instead of large-scale agriculture as practiced in North America. Japan has a total population of 127.11 million, according to the national population census in 2015, and approximately 26.0% of the population is older than 65 years. There has been a growing concern about farming as the current farmers are aging and struggle to find successors for their farms. Japan is also the second-largest agricultural product importer in the world. Rice accounts for almost all of Japan's cereal production. Due to the lack of arable land, a system of terraces is used for farming in small areas. There are more than 2700 river basins. However, most rivers are short and swift and flow erratically with little water available for use (FAO, 2006). Therefore, farms have developed reservoir irrigation systems to utilize river and pond water better, which is suitable for paddy rice fields in the lower plains.

Japan is now facing high depopulation, especially for municipalities where agriculture, forestry and fisheries workers have larger shares, the population decreases much more rapidly (Figure 2-2). Moreover, in Japan, the farming population is mainly aging people. People whose ages are over 65 years make up for 61 % of core persons mainly engaged in farming, while people whose ages are less than 50 years old account for only 10 % (Figure 2-3). That leads to the fact that the FLA area increases significantly because of the retirement of farmers. Therefore, it become urgent to examine the mechanism, determinants, and countermeasures of FLA in Japan based-on different scales and support agriculture activities in each specific context.

[1] https://www.theglobaleconomy.com/Japan/Share_of_agriculture/.

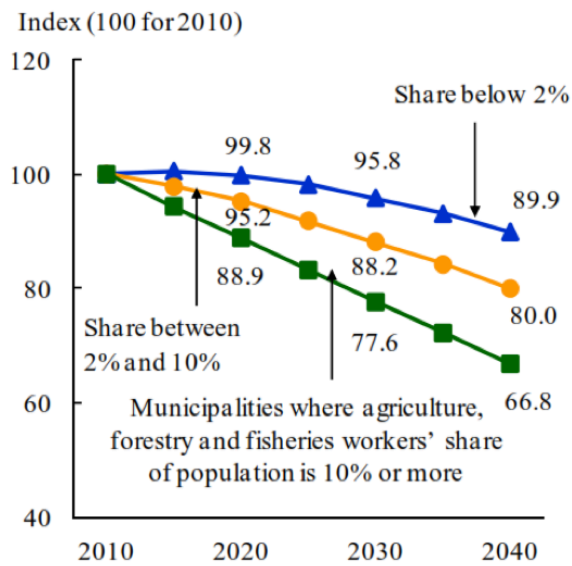


Figure 2-2 Changes in municipal population indexes (By share for agriculture, forestry, and fisheries workers)

Source: *MAFF, based on "Population Projections for Japan by Region (March 2013)" released by the National Institute of Population and Social Security Research).*

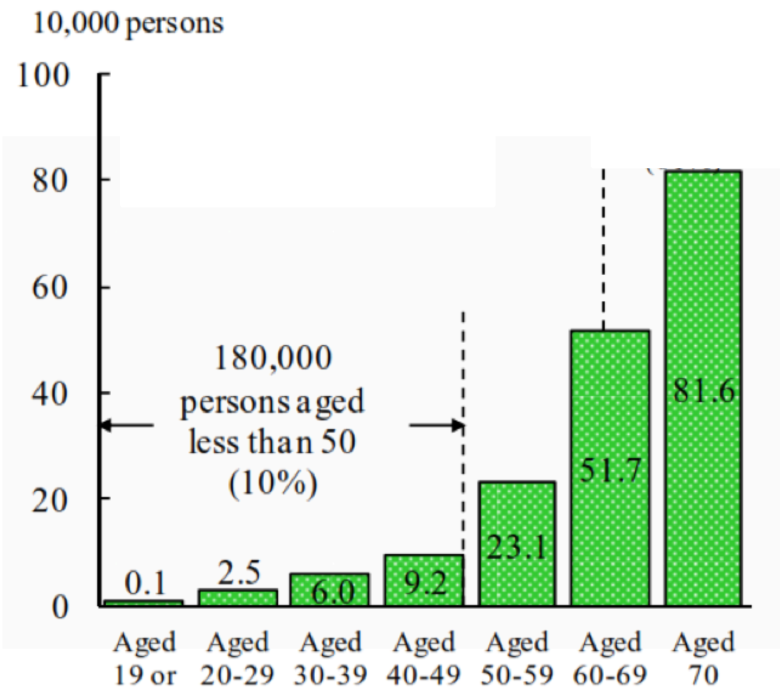


Figure 2-3 Core persons mainly engaged in farming by age group in 2013

Source: *MAFF, Survey on movement of agricultural structure.*

Over the course of Japan's economic growth, the share of employees in agricultural, forestry and fishery has become lower and lower every year, and their GDP share has also declined. Based on the statistical data of MAFF, the number of workers in the three industries decreased from 13.40 million in 1960 (30.2 % of the total workforce) to 2.23 million in 2016 (3.4 %), and the GDP share of the industries fell from 12.8 % in 1960 to 1.6 % in 2016 (Ministry of Land, Infrastructure & Land, 2018). Particularly, the share of agriculture industry in GDP has dropped from 1.69 % in 1995 to 1.1% in 2015 (Figure 2-4).

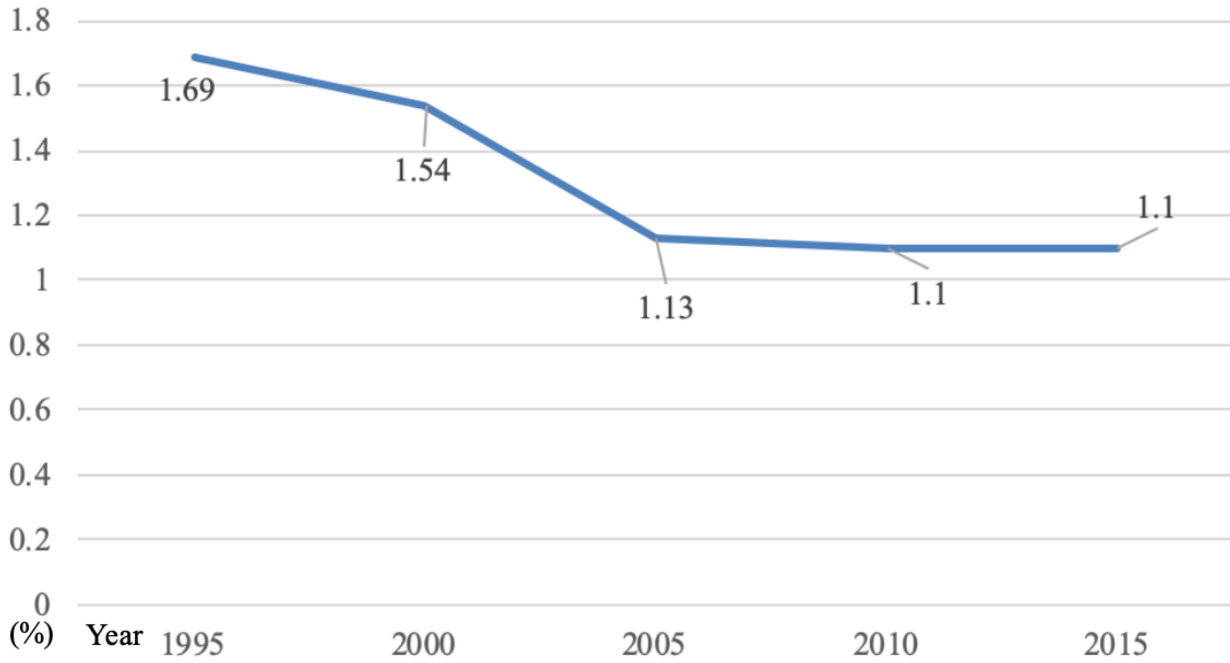


Figure 2-4 Agriculture share of GDP in Japan

Source: *MAFF.*

The share of different farmland types in total arable farmland area implies the current farmland condition and Japanese agricultural structure. Until 2018, nationwide arable farmland area (including both paddy field and cropland) was 4 397,000 hectares. Although there was a slightly increase of total arable farmland due to regeneration from abandoned farmland, diversion to residential area and other uses. As a result, the total areas decreased by 33,000 ha (0.5%) compared to the previous year. Among which, the area of the rice paddy field was 2.933,000 ha, a decrease of 12,000 ha (0.5%) compared to the previous year. The area of cropland was 24,000 ha, a decrease of 10,000 ha (0.5%) compared to the previous year (Figure 2-5). Agricultural production in Japan is dominated by rice production, though the predominance of rice has declined in recent decades as land is diverted from rice by a diversion program and because of the increase in the importance of commodities where proximity to markets is important (making imports poor substitutes), such as flowers and vegetables.

According to statistical data, rice accounted for almost 50% of agricultural production value in 1960, but only 23.1% till 2005, lower than vegetables (23.5%).

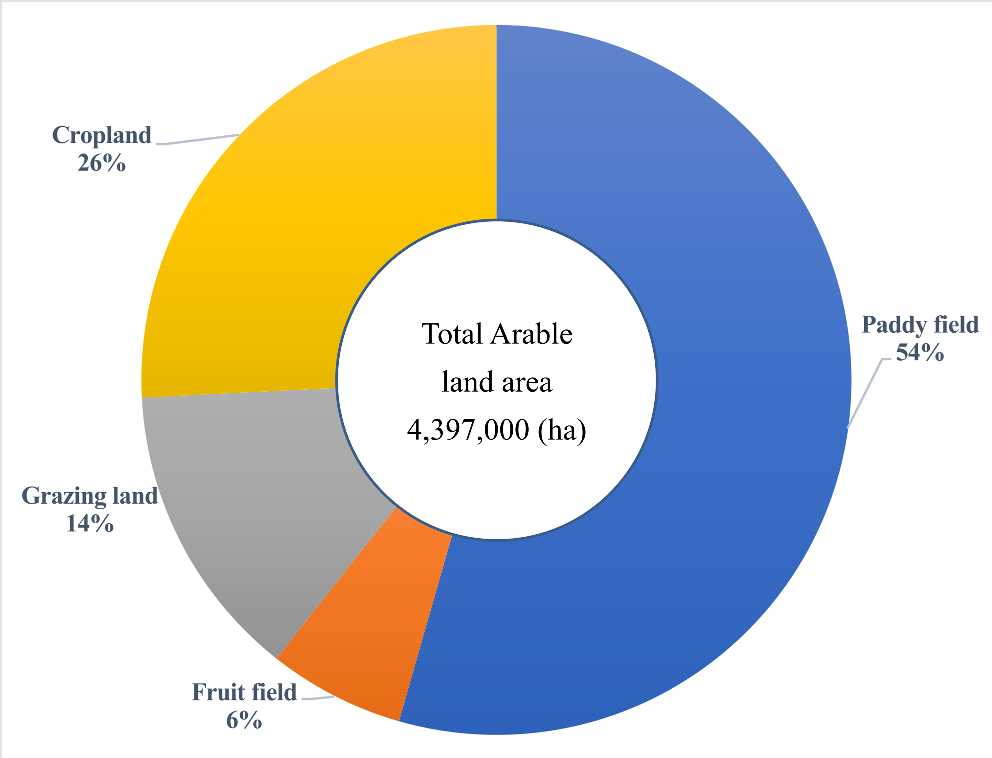


Figure 2-5 Area and ratio of farmland in Japan by type

Source: *MAFF, 2018.*

Table 2-1 clearly depicts the areas of arable land and their expansion and dilapidation[2] situation in different Prefectures in 2017. At a national level, the rate of cultivated land is 11.9%. The highest value was observed in Ibaraki Prefecture with 27.5%; Chiba and Saga Prefectures followed with values of 24.4% and 21.3%, respectively. While, the lowest rate of cultivated land was observed in Tokyo, with 3.1%. This is not surprising considering that Tokyo is the largest city of Japan and is dominated by metropolitan areas. Kochi and Yamanashi/Gifu Prefectures followed, with percentages of 3.9% and 5.3%, respectively. The arable farmland area in Hokkaido has the highest level, which also indicates the prosperous agriculture development and a different agriculture condition. The expansion and dilapidation of farmland in Japan imply that the overall speed of dilapidation is faster than the speed of expansion. In 2017, the total area of dilapidation was 34,200 ha, which is much greater than the total area of

[2] “Dilapidated Farmland” refer to a farmland that is not being actually cultivated, that has been dilapidated due to abandonment, and that is objectively not arable through usual agricultural practices.

expansion, 4,840 ha. Such development also reflects the declining trend of agriculture and the increase of FLA in Japan.

Table 2-1. Area of arable land, and expansion and dilapidation of farmland by Prefecture (2017) (Ha)

都道府県 Prefecture		耕地面積 Area of cultivated land					耕地率 Percent-age of culti-vated land	拡張 Expansion		かい廃 Dilapidation	
		総数 Total			田 Paddy fields	畑 Fields		田 Paddy fields	畑 Fields	田 Paddy fields	畑 Fields
			本地 Fields proper	けい畔 Attached dyke			(%) 1)				
全国	**Japan**	**4,444,000**	**4,267,000**	**177,300**	**2,418,000**	**2,026,000**	**11.9**	**3,340**	**4,500**	**16,600**	**17,600**
北海道	Hokkaido	1,145,000	1,127,000	17,900	222,300	922,700	14.6	36	701	389	1,560
青森	Aomori	151,500	147,300	4,210	80,000	71,500	15.7	159	408	841	553
岩手	Iwate	150,500	142,500	8,000	94,300	56,200	9.9	20	30	210	180
宮城	Miyagi	127,800	123,200	4,550	105,500	22,200	17.5	450	270	599	906
秋田	Akita	148,200	142,800	5,400	129,500	18,700	12.7	11	133	610	276
山形	Yamagata	118,400	113,400	4,990	93,600	24,800	12.7	2	153	646	476
福島	Fukushima	141,700	136,000	5,750	99,700	42,000	10.3	229	36	883	822
茨城	Ibaraki	167,500	165,100	2,400	97,400	70,100	27.5	133	480	780	1,560
栃木	Tochigi	123,900	120,600	3,320	96,800	27,100	19.3	151	157	313	288
群馬	Gumma	69,500	67,000	2,470	26,400	43,100	10.9	21	63	433	1,090
埼玉	Saitama	75,200	73,900	1,240	41,600	33,500	19.8	13	98	414	335
千葉	Chiba	125,700	122,100	3,600	74,000	51,700	24.4	4	12	244	366
東京	Tokyo	6,900	6,800	98	259	6,640	3.1	2	16	12	105
神奈川	Kanagawa	19,200	18,700	539	3,760	15,500	7.9	2	7	37	186
新潟	Niigata	170,700	161,600	9,120	151,400	19,300	13.6	57	119	580	193
富山	Toyama	58,500	56,400	2,120	55,900	2,560	13.8	12	37	206	10
石川	Ishikawa	41,500	40,400	1,120	34,500	6,960	9.9	5	63	288	82
福井	Fukui	40,300	39,400	989	36,600	3,760	9.6	7	18	140	24
山梨	Yamanashi	23,800	23,100	773	7,920	15,900	5.3	38	101	104	202
長野	Nagano	107,300	98,100	9,270	53,100	54,200	7.9	29	106	425	410
岐阜	Gifu	56,300	52,900	3,360	43,100	13,200	5.3	47	106	379	140
静岡	Shizuoka	66,400	64,100	2,320	22,400	44,000	8.5	120	169	251	742
愛知	Aichi	75,700	72,100	3,600	43,000	32,700	14.6	2	17	332	313
三重	Mie	59,300	56,400	2,950	45,000	14,400	10.3	15	8	266	305
滋賀	Shiga	52,100	49,800	2,300	48,100	4,010	13.0	7	9	292	83
京都	Kyoto	30,600	28,700	1,820	23,900	6,710	6.6	26	13	192	42
大阪	Osaka	12,900	12,400	567	9,140	3,790	6.8	28	43	209	9
兵庫	Hyogo	74,200	67,900	6,230	67,800	6,400	8.8	2	20	469	92
奈良	Nara	20,900	19,300	1,610	14,800	6,090	5.7	29	41	405	148
和歌山	Wakayama	32,800	31,200	1,600	9,610	23,200	6.9	14	25	138	420
鳥取	Tottori	34,500	31,800	2,750	23,500	11,000	9.8	74	106	157	165
島根	Shimane	37,000	33,700	3,240	29,800	7,120	5.5	20	19	199	120
岡山	Okayama	65,600	59,600	5,980	51,300	14,200	9.2	209	147	469	285
広島	Hiroshima	55,300	50,100	5,190	41,200	14,000	6.5	8	0	169	226
山口	Yamaguchi	47,700	43,200	4,450	39,100	8,530	7.8	10	7	226	182
徳島	Tokushima	29,300	28,400	873	19,700	9,530	7.1	1	2	174	100
香川	Kagawa	30,500	28,400	2,120	25,300	5,160	16.3	39	35	272	85
愛媛	Ehime	49,400	46,300	3,040	22,800	26,600	8.7	2	18	228	308
高知	Kochi	27,600	26,100	1,510	20,800	6,770	3.9	3	5	189	71
福岡	Fukuoka	82,600	78,700	3,870	65,700	16,900	16.6	43	51	822	597
佐賀	Saga	52,100	49,500	2,560	42,500	9,580	21.3	0	28	300	267
長崎	Nagasaki	47,200	43,600	3,610	21,600	25,600	11.4	7	20	409	440
熊本	Kumamoto	111,800	103,900	7,910	68,600	43,200	15.1	1,220	68	336	1,100
大分	Oita	55,600	51,600	4,060	39,700	15,900	8.8	23	20	348	200
宮崎	Miyazaki	66,800	63,400	3,370	36,100	30,700	8.6	-	58	635	222
鹿児島	Kagoshima	119,000	111,700	7,340	38,000	81,100	13.0	1	8	605	736
沖縄	Okinawa	38,000	36,800	1,230	822	37,200	16.7	6	448	22	622

Source: *Statistics Bureau, Ministry of Internal Affairs and Communications*

Retrieved from https://www.stat.go.jp/english/data/nenkan/68nenkan/1431-08.html.

To know the farm household structures can also help in understanding agriculture condition. In Japan, the total set of farm households[3] consists of self-sufficient farm households[4], commercial farm households[5] and land tenure non-farm households. Agricultural management entities[6] refer to the combination of commercial farm households, agricultural holdings other than a farm household, and agricultural service enterprises. In 2015, the number of farm households engaged in commercial farming was 1.33 million. Of these commercial farm households, 33.3 % were full-time farm households, 12.4 % were part-time farm households, and 54.3 % were part-time farm households (Table 2-2). There are two types of part-time farmers. The first type part-time refers to households where at least one member is engaged in non-farm employment and whose farm income exceeds their non-farm income, while the second type is households where at least one member engages in non-farm employment and whose non-farm income exceeds their farm income (Heller, 2016). Of the commercial farm household members, 2.10 million people were engaged in farming as their principal occupation (commercial farmers) in 2015, of whom 63.5 % were aged 65 years and over (Statistics Bureau, 2018).

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[3] Household engaged in farming and managing cultivated land of 10 Acres or more or earning more than 150,000 yen per year from sales of agricultural products. (An acre is 100 square meters)

[4] A farm household managing cultivated land of less than 30 Acres and earning less than 500,000 yen per year from sales of agricultural products.

[5] Farm household managing cultivated land of 30 Acres or more or earning more than 500,000 yen per year from sales of agricultural products.

[6] An establishment that either performs agricultural production directly or on contract and fulfills one of the following conditions: (1) manages 30 Acres or more cultivated land, (2) possesses a planted area or cultivated area or a number of livestock being raised or delivered that is equal to or greater than a predetermined standard (e.g. 15 Acres for outdoor grown vegetables, 350 square meters for vegetables grown in facilities, one cow), (3) accepts farm work on contract.

Table 2-2. Commercial farm households and commercial farmers

Year	Commercial farm households (1,000)				Commercial farmers	
	Total	Full-time	Part-time		(1,000)	Aged 65 years and over (%)
			Type 1 Mainly farming	Type 2 Mainly other job		
1995	2,651	428	498	1,725	4,140	43.5
2000	2,337	426	350	1,561	3,891	52.9
2005	1,963	443	308	1,212	3,353	58.2
2010	1,631	451	225	955	2,606	61.6
2015	1,330	443	165	722	2,097	63.5

Source: *MAFF.*

2.1.1 National scale

For the national scale analysis, this study considered the national context of Japan, including 47 Prefectures in 7 main regions: Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku Shikoku and Kyushu regions (Figure 2-6). Research data were derived from the National Census of Agriculture and Forestry in 2015 (in Japanese: 2015 *Noringyo* Census). Japan is the only country in the world that has data to monitor the change of FLA every 5 years. Such data are valuable to provide an explicit understanding of temporal variations and regional differences of FLA. In addition, Digital elevation models (DEMs) are distributed by the Geospatial Information Authority of Japan (GSI), with a spatial resolution of 10 meters. Geographical variables were calculated from raster maps, whereas most socio-economic variables were available and are displayed in the form of polygons at the former municipality level (Figure 2-7).

There are two main reasons for selecting boundaries of former municipalities, in this case from 1950, at a national scale: Contemporary administrative units are too large to describe regional variations in detail; in contrast, agricultural settlement units are too small to have sufficient data support. However, there is a disadvantage in using former municipalities. In order to preserve household privacy, the local government refused to provide real data of their exact location because of the limited number of farm households in some regions. In the calculation, the author carefully examined and excluded municipalities with limited data, and finally retained 9368 municipalities.

All the processes were calculated using SPSS Statistics 21.0 (IBM SPSS Japan: Tokyo, Japan), ArcGIS 10.3 (ESRI Japan: Tokyo, Japan), and Geoda (the University of Chicago, Chicago, USA) software packages.

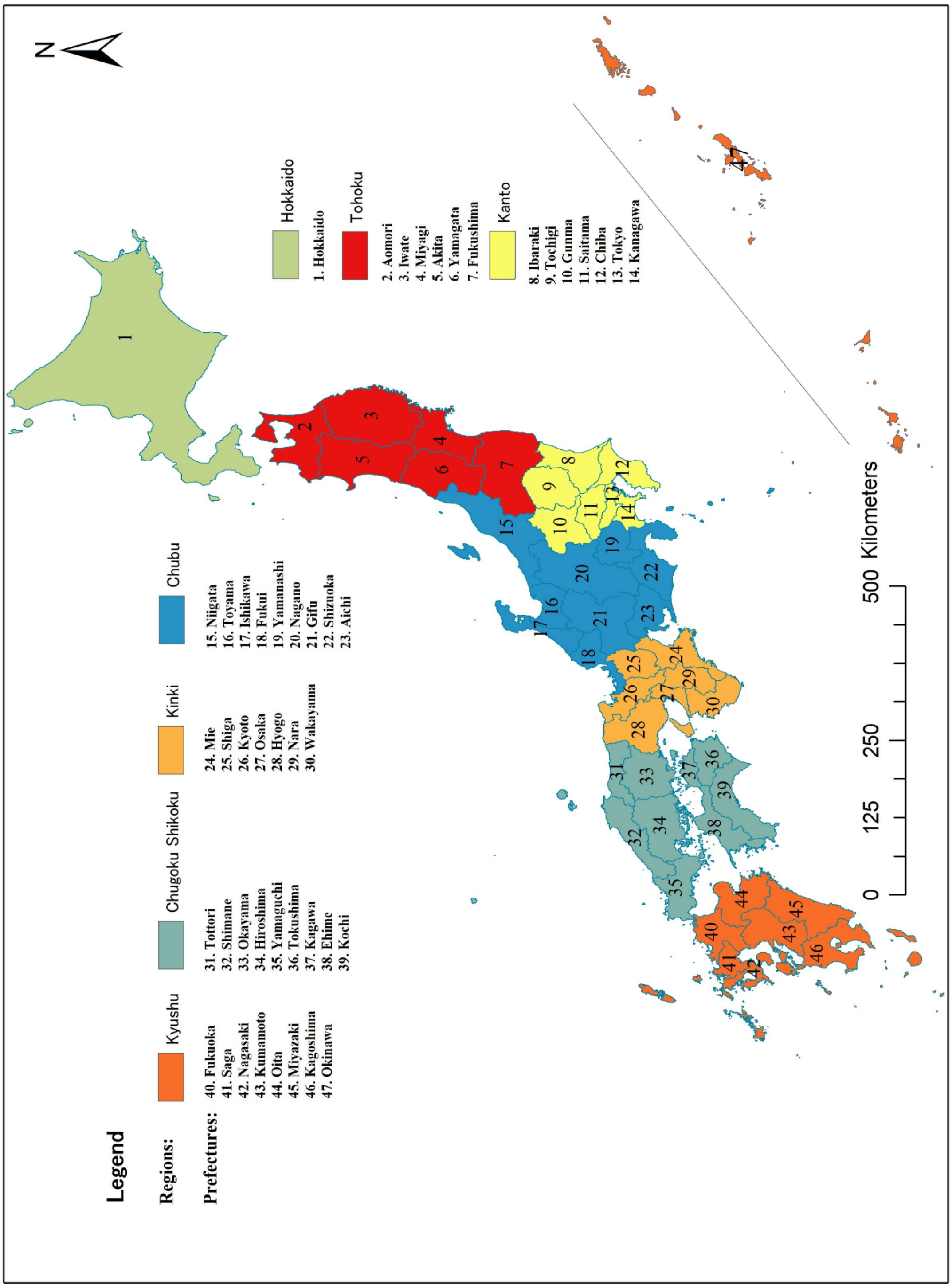


Figure 2-6 Prefectures and regions of Japan

Source: *DEM: Geospatial Information Authority of Japan (GSI), https://fgd.gsi.go.jp/download/menu.php.*

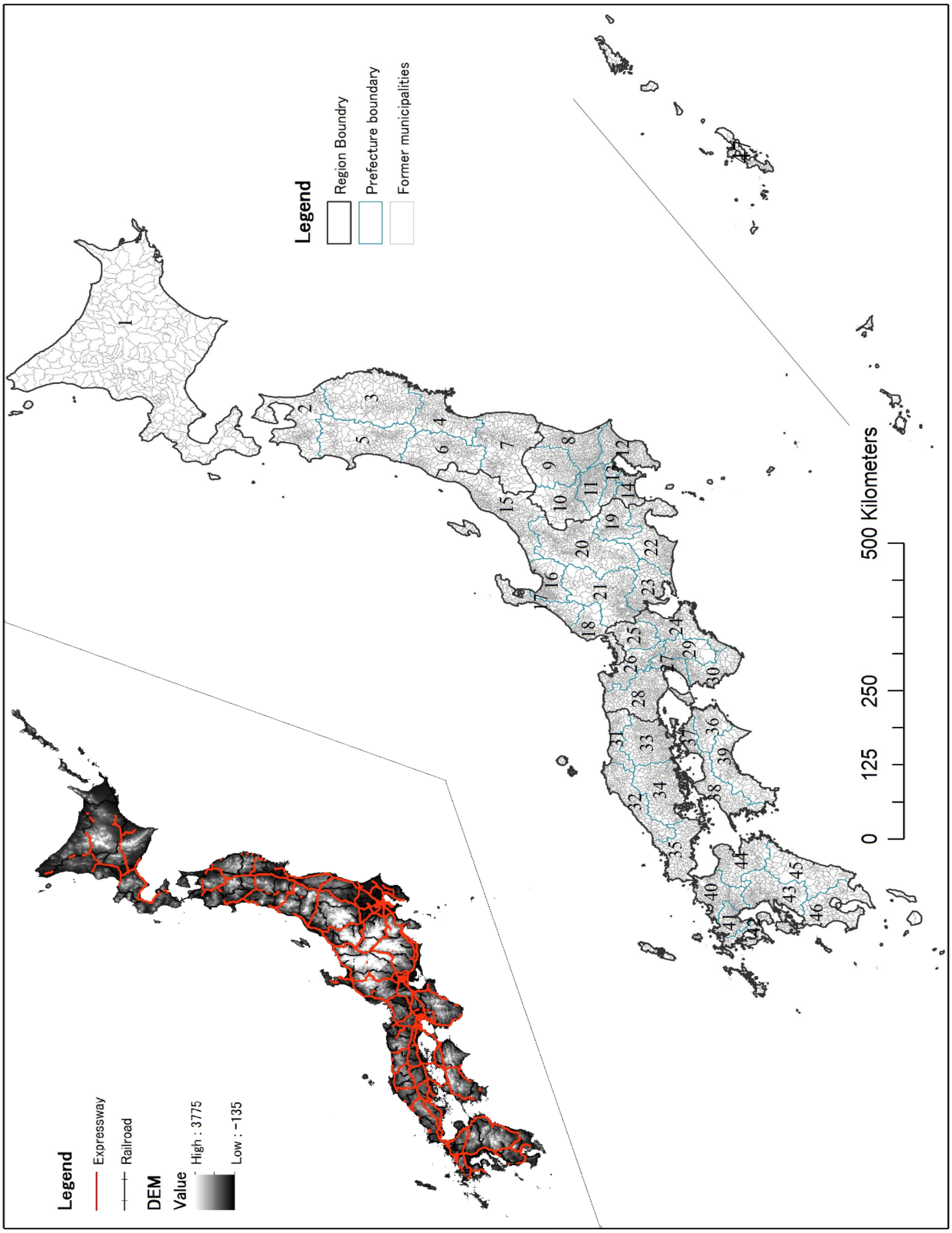


Figure 2-7 Geographical characteristics of the former municipalities

Source: *DEM: Geospatial Information Authority of Japan (GSI), https://fgd.gsi.go.jp/download/menu.php; Road networks: National land numerical information download service, http://nlftp.mlit.go.jp/ksj-e/jpgis/jpgis_datalist.html.*

2.1.2 Intraregional scale: case in the Chugoku and Shikoku region

For the intraregional scale analysis, this study selected the Chugoku and Shikoku region as a research target as this region and experienced the highest FLA rate until 2015. The Chugoku and Shikoku region is the combination of the Chugoku subregion (Chugoku-Chiho) located in the westernmost part of Honshu island, and the Shikoku subregion (Shikoku-Chiho) which is an isolated island just next to Chugoku subregion (Figure 2-8). In terms of administrative units, the Chugoku subregion consists of the Prefectures of Hiroshima, Yamaguchi, Shimane, Tottori, and Okayama that cover an area of about 31,900 km^2. The Shikoku subregion covers about 18,800 km^2 and consists of four Prefectures: Ehime, Kagawa, Kochi, and Tokushima. The Chugoku and Shikoku region is basically regarded as one region; however, Chugoku and Shikoku subregions differ in their geographical composition (Figure 2-9). As regards elevation, Chugoku and Shikoku subregions show remarkable differences. The mountain ranges in Chugoku subregion run from east to west and stretch across the interior territory with gentle slopes. In contrast, in the Shikoku subregion mountains are characterized by their bumpiness and steepness (Kanzaka, 2009). In between, the Seto-Inland Sea functions as a belt separating Chugoku and Shikoku subregions. Due to the variations of geographical conditions, agriculture has exhibited great intraregional characteristics in different former municipalities and which might be strongly connected to the FLA in this region.

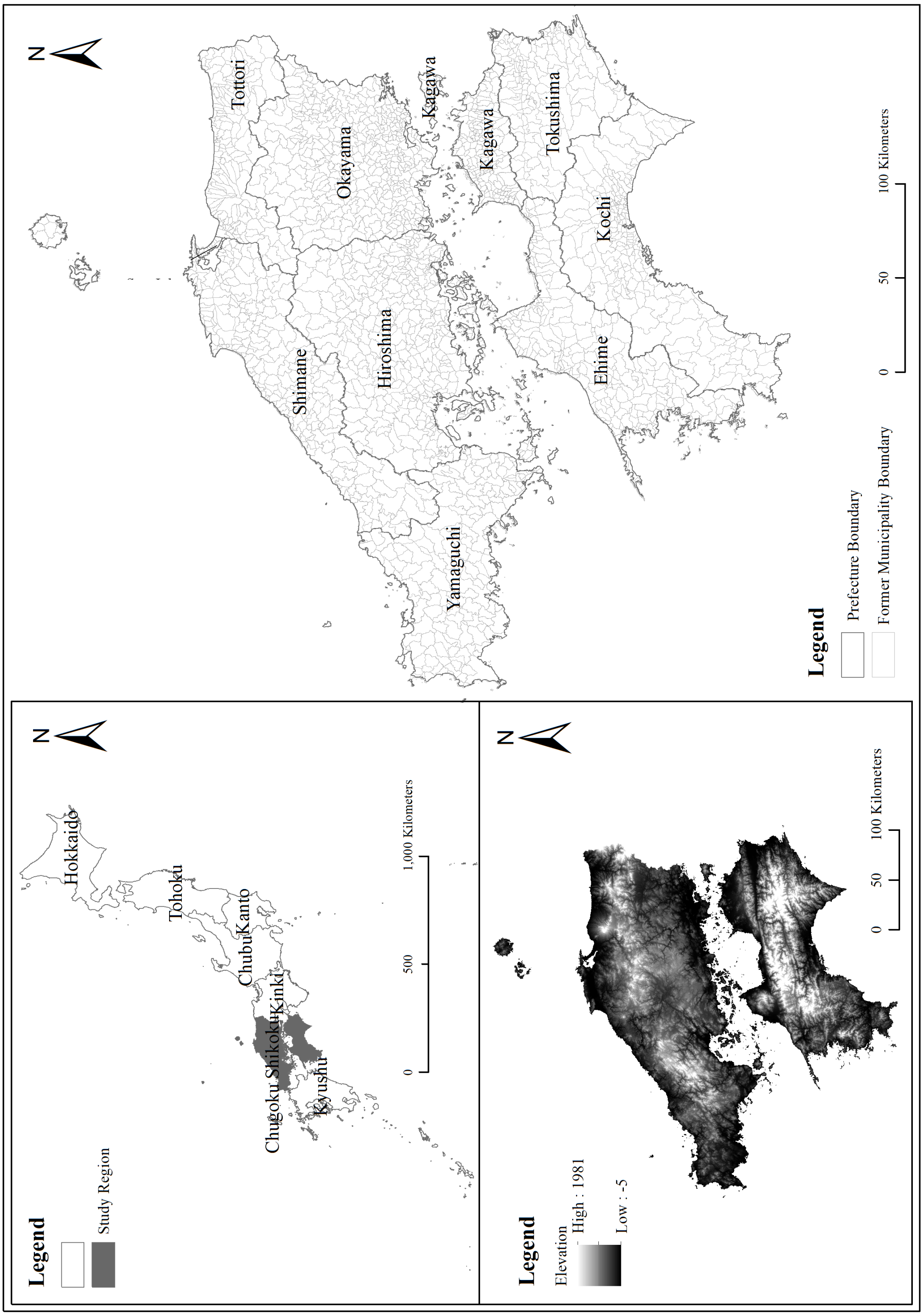


Figure 2-8 Location of study region (intraregional scale)

Source: *MAFF, DEM: Geospatial Information Authority of Japan (GSI), https://fgd.gsi.go.jp/download/menu.php; Road networks: National land numerical information download service, http://nlftp.mlit.go.jp/ksj-e/jpgis/jpgis_datalist.html.*

2.1.3 Local scale: case in the Hiroshima Prefecture

In the specific local-level case study, the targeted area is Hiroshima Prefecture, Japan (Figure 2-10). Until 2018, Hiroshima Prefecture had the highest FLAR based on national agriculture census (about 27.14%). There were 275 Incorporated Community-Based Farm Cooperatives (details will be explained in the Chapter 5) (ICBFCs) in Hiroshima Prefecture in total[7]. The individual farm households (24 households) and ICBFCs (275 ICBFCs) were targeted to conduct the main surveys. Opinions from both individual farm households and ICBFCs support us to understand the issue of FLA in Japan and try to look for promising countermeasures.

The general characteristics of agriculture development in Hiroshima Prefecture are as below:

Scale of agricultural management is relatively small, while the number of agricultural workers is decreasing continually, and the abandoned farmland areas are increasing. In addition, HMAs occupy nearly three-quarters of the Prefecture territories so that agriculture production conditions are challenging. As a result, agricultural income is low compared with the nationwide level (Imai et al., 2008). Agriculture in Hiroshima Prefecture has a great diversity due to variety of weather conditions, such as snow-covered area along mountains in the north and temperate islands in the south.

[7] https://www.pref.hiroshima.lg.jp/soshiki/81/shuurakuhoujinnseturitujyoukyou20150316.html

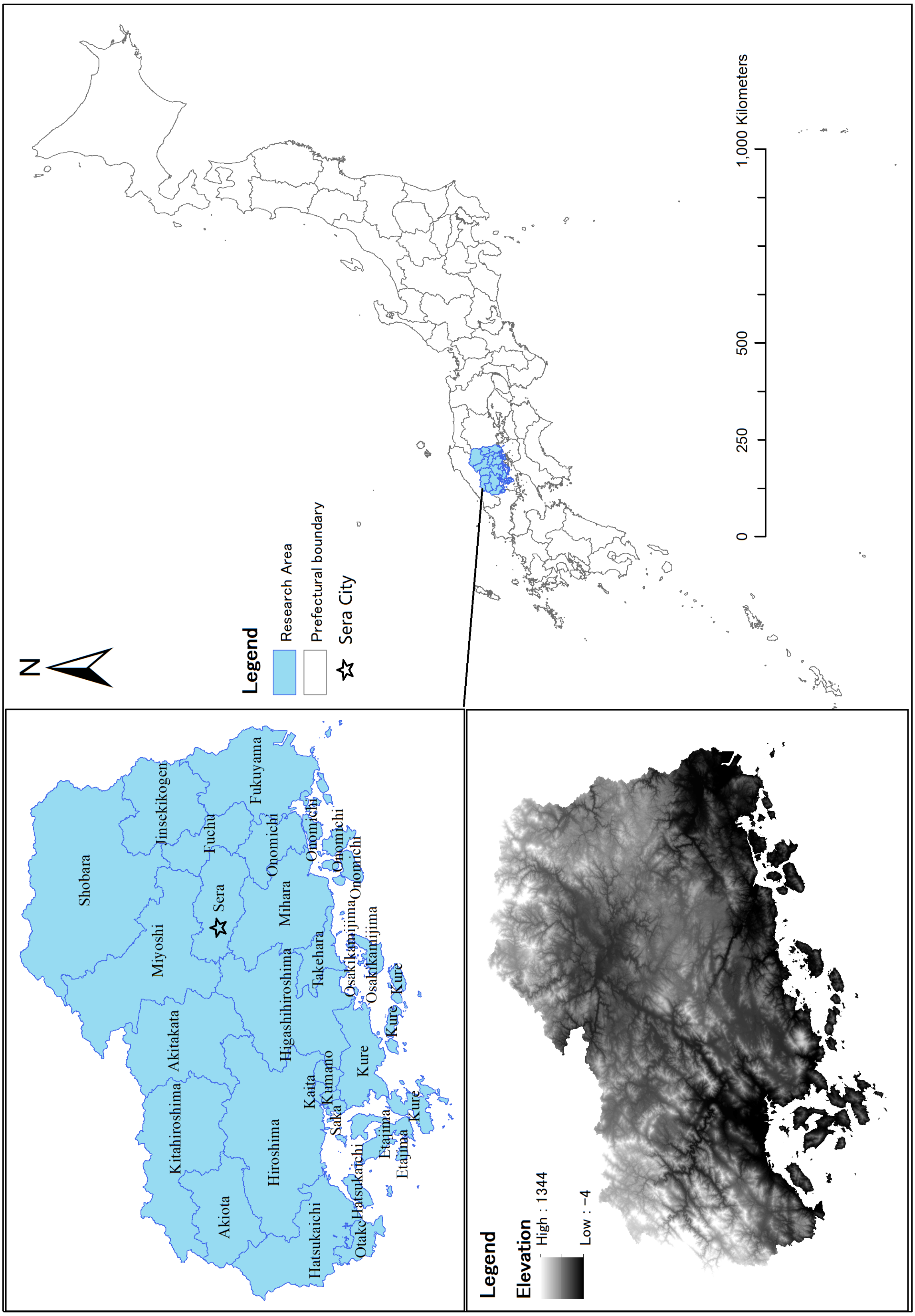


Figure 2-9 Location of study area (local scale)

2.2 Research Data

2.2.1 Data from the national scale

As stated in the introduction, determinants of FLA are usually assessed by different scholars into environmental (natural) and socio-economic aspects (Rey Benayas, 2007). Environmental factors refer to meteorological factors such as precipitation (Yamaguchi et al., 2016), temperature (Prishchepov et al., 2013), ecological factors such as soil condition (Zhang et al., 2014; Arika & Mazure, 2017; Londoño et al., 2017), forest rate (Sang et al., 2014) and geographical factors such as slope and elevation (Kolecka et al., 2017; Díaz et al., 2011; Pazúr et al., 2014). In Japan, meteorological factors have been discussed by Osawa (2016) at the 10 × 10-km^2 mesh scale (Osawa et al., 2016). For the national scale analysis: geographical conditions that are available from former municipalities were considered, such as slope (Müller et al., 2013) and remoteness or accessibility (Díaz et al., 2011; Gellrich et al., 2007; Lieskovský et al., 2015). "X1: Mean slope", "X2: Expressway density" and "X3: Railroad density" were introduced to present the geographical condition of each municipality (Table 2-3). The calculation utilizes the mean center of each municipality and projected the slope value onto the center.

For the selection of socio-economic determinants: The theories used to explain FLA are based on socio-economic conditions of human behavior or economic conditions (Prishchepov et al., 2013; Gellrich et al., 2007). Socio-economic conditions are difficult to measure, and sometimes researchers cannot cover all the situations. MAFF usually conducts its census based on farm households, to represent the condition in the municipality. To abandon farmland or not is usually a household decision that depends on the household and farmland characteristics (Li & Li, 2017; Rey Benayas, 2007). In this study, socio-economic factors were categorized into farm-household-related and farmland-related groups (Table 2-4). To describe the household land tenure structure, "X4: Arable land ratio of self-sufficient farm households" and "X5: Arable land ratio of land tenure non-farm households" were selected. Self-sufficient households potentially produce and consume the agricultural products themselves, while non-farm households have lower utilization of their farmland. Both types are considered to be more likely to abandon their farmland than households that are fully engaged in agriculture. "X6: Arable land area per farm household", which shows the household farming scale (Ito et al., 2016), was also included. To evaluate the farm household, "X7: Ratio of the first type of part-time farm households" was selected to evaluate the farm households' income structure (Morimoto, 1993). There are two types of part-time farm households, the first type means households where at least one member is engaged in non-farm employment and whose farm income exceeds their non-farm income, while the second type denotes households where at least one member engages in non-farm employment and whose non-farm income exceeds their farm income (MAFF 2010). This analysis evaluated farm households' laborers and successors to represent their labor situation. Households with insufficient agricultural laborers and a lack of successors were found to be inclined to abandon their farmland (Pazúr et al., 2014; Zhang et al., 2014). Consequently, "X8: Laborers per farm household" and "X9: Ratio of non-successor farm households" were selected.

For farmland-related variables, land tenancy and its extent were mainly considered. An empirical study on FLA showed that the leasing of farmland could be a promising measure to prevent abandonment (Kawashima, 2010). "X10: Ratio of leased (tenanted) land" and "X11: Ratio of leased-out land" were therefore selected to test this assumption. In Japan, the majority of arable land is rice paddy fields, which have a profound connection with FLA (Fukamachi, 2017). As a result, "X12: Paddy field density" was selected as an essential variable. Table 4 shows the socio-economic variables and their description for the evaluation of socio-economic conditions in each municipality. Variables from 2010 and 2015 were available as study periods, while this study displayed data from 2015, which are closer to the current situation, and data from 2010 were used for verification.

Table 2-3. Explanatory determinants (Geographical factors) (2015) (N=9368)

Type of Variable	Description	Min	Max	Mean	SD
Dependent variable (Former municipality level, *N* = 9368)					
Y FLAR	Abandoned land area/(abandoned land area + total arable land area) (%)	0	100	21.31	17.83
Independent variables (Former municipality level, *N* = 9396)					
Geographical factors:					
X1 Mean slope (meters)	To define the steepness	0	38.84	13.20	9.85
X2 Expressway density (kilometers/square kilometers)	To describe access by the expressway	0	2.12	0.047	0.11
X3 Railroad density (kilometers/square kilometers)	To describe access by railroad	0	11.85	0.050	0.20

Table 2-4. Explanatory determinants (Socio-economic factors) (2015) (N=9368)

Type of Variable	Description	Min	Max	Mean	SD
Independent variables (Former municipality level, *N* = 9368); Socio-economic factors:					
Farm household related:					
X4 Arable land ratio of self-sufficient farm households (TH)	Self-sufficient household arable land area/total arable land area (%)	0	100	15.30	17.57
X5 Arable land ratio of land tenure non-farm households (TH)	Non-farm household arable land area/total arable land area (%)	0	100	25.12	73.04
X6 Arable land area per farm household (TH)	Total arable land area/total farm households (ha)	0.08	107.78	1.27	3.49
X7 Ratio of the first type of part-time farm household (BH)	The first type of part-time farm household/total farm households (%)	0.51	75	11.78	7.46
X8 Laborers per farm household (BH)	Total agricultural laborers/total farm household (people)	0.25	3.78	1.53	0.36
X9 Ratio of non-successor farm households (BH)	Farm households without successors/total farm households (%)	11.11	100	71.02	11.66
Farmland-related factors:					
X10 Ratio of leased-in land (ME)	Leased (tenanted) land area/total arable land area (%)	0	100	35.52	19.36
X11 Ratio of leased-out land (ME)	Leased-out land area/total arable land area (%)	0	100	5.78	5.93
X12 Paddy field density (ME)	Paddy field area/total arable land area (%)	0	100	71.08	28.45

TH: Data were derived from total farm households; BH: Data were derived from commercial farm households; ME: Data were derived from total agriculture management entities. Source: *Variable data: Ministry of Agriculture, Forestry and Fishery (MAFF), http://www.maff.go.jp/e/index.html; DEM: Geospatial Information Authority of Japan (GSI), https://fgd.gsi.go.jp/download/menu.php.*

2.2.2 Data from the Intraregional scale

From the intraregional scale, this study carefully examined and excluded municipalities with limited data, and finally retained 9368 municipalities in the study region. All the processes were calculated using SPSS Statistics 21.0 (IBM SPSS Japan: Tokyo, Japan), ArcGIS 10.3 (ESRI Japan: Tokyo, Japan), and Geoda software packages.

To evaluate the impact of agricultural characteristics on FLA, this analysis collected factors regarding agricultural characteristics in the Chugoku and Shikoku region. Based on previous studies and understanding the agriculture context in the region, 25 variables or attributes were finally extracted from the region via the 2015 census of agriculture and forestry (Table 2-5). Three types of farm units were taken into consideration: total farm households, business farm households, and total agriculture management bodies.

For many years, MAFF conducted surveys of "individual farm households" that mainly engaged in agriculture to represent the average situation across the municipality. However, in recent years, the number of organizations, companies, and agricultural cooperatives engaged in farming has increased, and it has become difficult to understand the entire agricultural structure by focusing solely on farm households. Therefore, in 2005, the concept of "agricultural management body," which refers to both agricultural management (family management body) by households and organizational management (organization management body) such as companies and agricultural corporations, was introduced (MAFF, 2015). Table 2-3 provides the definitions of the variables along with descriptive statistics. For the data analysis, the former municipalities in 1950 were selected as sample units, similar to the agricultural census.

As the independent variables differ in range of variance, a normalization technique was applied to transform each variable in the dataset to a specific range (0–1); it is thus essential that the data be normalized prior to the implementation of principal component analysis (PCA) (Uddin et al., 2019). In this study, before statistical analysis, normalization was conducted using the following equation:

$$Xi = \frac{Xi - Xmin}{Xmax - Xmin} \tag{1}$$

Where, *Xi* is an observed value in an array of observed values for a variable; *Xmax* is the highest value in the same array; *Xmin* is the lowest value.

Table 2-5. Description of variables for assessing agricultural characteristics and FLA (N=2354)

Type of variables	Description	**Min**	**Max**	**Mean**	**S.D.**
Dependent variable B. FLAR (TH)	Abandoned land area / (abandoned land area + total arable land area) *100 (%)	0	100	27.12	18.25
Independent variables					
A1 Forest rate	Forest land area/Total land area*100 (%)	0	99	60.67	25.71
A2 Arable land ratio of self-sufficient farm households (TH)	Self-sufficient household arable land area / total arable land area*100 (%)	0	100	19.56	18.75
A3 Arable land ratio of land tenure non-farm households (TH)	Non-farm household arable land area / total arable land area *100 (%)	0	100	20.83	14.63
A4 Arable land area per household (TH)	Total arable land area / total farm households *100 (Ha)	0	3	0.64	0.33
A5 Ratio of business farm household (TH)	Business farm households / Total farm households*100 (%)	2	100	54.85	20.26
A6 Share of land tenure non-farm household (TH)	Land tenure non-farm households / Total farm households *100 (%)	5	940	76.45	81.16
A7 Ratio of the first type part-time farm households (BH)	The first type part-time farm households / total farm households*100 (%)	1	67	8.93	5.82
A8 Ratio of the second type part-time farm households (BH)	The second type part-time farm households / total farm households *100 (%)	2	100	54.37	16.06
A9 Farmer's average age (BH)	Total farmers average age (years old)	48	81	69.60	3.28
A10 Labors per farm household (BH)	Total agricultural laborers / Total farm households (People)	0	3	1.45	0.29
A11 Ratio of workers below 65 years (BH)	Younger than 65-year-old worker / Total agriculture workers	0	100	33.08	10.91
A12 Ratio of non-successor farm households (BH)	Total farm households without successors / total farm households *100 (%)	17	100	74.89	11.36
A13 Solely rice production farm household rate (BH)	Rice production farm households / total farm households *100 (%)	0	100	60.92	26.63
A14 Solely vegetable production farm household rate (BH)	Vegetable production farm households / total farm households *100 (%)	0	94	9.63	14.64
A15 Solely fruits production	Fruits production farm households / total farm	0	100	18.65	26.95

farm household rate (BH)	households *100 (%)				
A16 Solely husbandry production farm household rate (BH)	(Dairy single + beef cattle single + pig single + chicken single + sericulture single + other livestock single) / total farm households *100 (%)	0	95	1.34	4.15
A17 Combined management farmers rate (BH)	Number of combined management farm households / total farm households *100(%)	0	40	4.98	4.26
A18 Ratio of leased-in land (MB)	Leased-in land area / total arable land area *100 (%)	0	100	30.34	17.02
A19 Ratio of leased-out land (MB)	Leased-out land area / total arable land area*100 (%)	0	85	5.34	5.83
A20 Paddy field rate (MB)	Paddy field area / total arable land area *100 (%)	0	100	74.30	26.11
A21 Crop land rate (MB)	Crop land area / total arable land area *100 (%)	0	100	14.16	16.34
A22 Fruit land rate (MB)	Fruit land area/ total arable land area*100 (%)	0	100	13.72	23.64
A23Rice commissioned work management body rate (MB)	Rice commissioned work management entity / Total management bodies *100 (%)	0	45	7.44	4.70
A24 Rate of farm households with more than 10 million yen in sales (MB)	More than 10-million-yen sales value farm household / total farm households *100 (%)	0	100	4.03	7.23
A25 Share of agriculture management bodies with less than 0.5 ha farmland (MB)	Agriculture management bodies with less than 1 ha farmland / Total agriculture management bodies *100 (%)	0	100	33.03	18.01

TH: data is derived from total farm households; BH: data is derived from business farm households; MB: data is derived from total agriculture management bodies

Source: *Ministry of Agriculture, Forestry and Fishery (MAFF), http://www.maff.go.jp/e/index.html.*

2.2.3 Data from the local scale

Sera city (Figure 2-9) was selected as a target because agriculture in terms of community-based farming were developing rapidly in recent years. Through the evidence from Sera town, we can know how local farm households preserve agriculture and deal with FLA. Research data for the local scale are chiefly derived from surveys (Table 2-6). The first survey targets on people who come to Sera roadside station for travelling and shopping (N=101). The second survey targets on individual farm households in ICBFCs including 24 households: *Kirarikariyama* (15 households) and *Kurohada* (9 households) (Figure 2-11). The survey consists of two major objectives: for the first survey, the author investigated local people opinions by asking questions regarding FLA including its determinants, people's attitudes and future plan. The 101 respondents were not only limited to local people; it was randomly selected from people who went to Sera roadside station on the survey date. Questions include their personal information (such as age, gender, educational background, family etc.), consumption preference (frequencies, means of transportation, place) and their attitude toward FLA and future agriculture development (Appendix IX). For the second survey, it was conducted in individual farm households. The survey included information from four perspectives: personal information of respondents such as name, age, gender and the relationship with household head, household members, plan and purpose of doing agriculture, reasons of FLA and future successors etc., and basic information regarding farmland including leased and lease out farmlands (Appendix X). Such information can reflect the situations of individual farm households and their contribution to the local agriculture development.

Figure 2-10 Questionnaire survey of individual farm households in Sera town, Hiroshima Prefecture

Source: *author.*

Table 2-6. Questionnaire survey of individual farm households in Hiroshima Prefecture

Survey organization	**Geography lab, graduate school of letters, Hiroshima University**
Objective	Farm households and people in Sera, Hiroshima Prefecture
Survey period	June 2017 and February 2018.
Survey method	By visiting Sera town, Hiroshima and distributing questionnaire
Questionnaire	For farm households, questions include their family information and opinions on agriculture and FLA For people in Sera roadside station, questions are about their awareness of FLA.
Response rate	24 farm households and 101 people in Hiroshima Prefecture

To achieve the research goals and fully understand how ICBFCs contribute to maintaining local agriculture and management of FLA, this analysis selected Hiroshima Prefecture as a case. For the local scale analysis, research data come from secondary statistical data by national agriculture census and questionnaire surveys. The Questionnaire survey was conducted in March 2019. The structured questionnaire aimed to capture the current situations of ICBFCs and their efforts to maintain local agriculture and to manage FLA. All the 275 ICBFCs were targeted in Hiroshima; 11 questionnaires were declined, and 168 questionnaires were successfully received and answered by 168 ICBFCs' representative person. The 168 samples mean that the proportion of the collected samples in the overall ICBFCs is 61.1% (Table 2-7). The questions of the survey consist of four parts (Appendix XI): first, questions relate to the basic information of ICBFCs were asked such as their name, year of establishment, management scale and the number of employees etc. Second, questions regarding FLA were asked to grasp the situation of FLA in the region and to know the opinions of local people of abandonment and agricultural development. Third, the connections and surrounding environment of ICBFCs were evaluated by asking questions of their frequencies of workshops, workshop themes, merits and demerits and future plans. At last, the information of representative person was acquired, which allows us to know the current status of ICBFCs and their effort to maintain local agricultural development comprehensively. Figure 2-12 depicts the change of the number of ICBFCs and until 2018. From 2005 to 2018, the number of ICBFCs experienced a rapid increase and there were 275 ICBFCs in Hiroshima Prefecture in 2018. The characteristics of the representative persons of ICBFCs are summarized in Table 2-8. Among all the respondents, 42.2% are aged 70–79 years, and 35.6% are aged 60–69 years; the most common education level is high school (49.7%), followed by junior college (20.3%) and university or above (17.8%). In addition, 99.4% of ICBFC representative persons are male and their household type is dominated by couple type (62.9%).

Table 2-7. Questionnaire survey of ICBFCs in Hiroshima Prefecture

Survey organization	**Geography lab, graduate school of letters, Hiroshima University**
Objective	Total 275 ICBFCs in Hiroshima Prefecture
Survey period	March to April 2019.
Survey method	By post, presentative person will answer the questionnaire and send it back
Questionnaire	There are total 28 questions (basic information, business statues, future plans, representative person etc.)
Response rate	168 questionnaires have been received. Response rate is 61.1%

Table 2-8. Basic information of representative persons of ICBFCs (N=168)

Individual characteristics		**Percentage (%)**
Sex	Male	99.4
	Female	0.6
Age	<30 years old	0.6
	30-39 years old	0.6
	40-49 years old	2.4
	50-59 years old	5.4
	60-69 years old	35.6
	70-79 years old	42.2
	Above 80 years old	13.2
Education level	Secondary school	3.1
	High school	49.7
	Junior college	20.2
	University or above	17.8
	Others	9.2
Household Type	Single	3.1
	Couple	62.9
	Couple and children	10.7

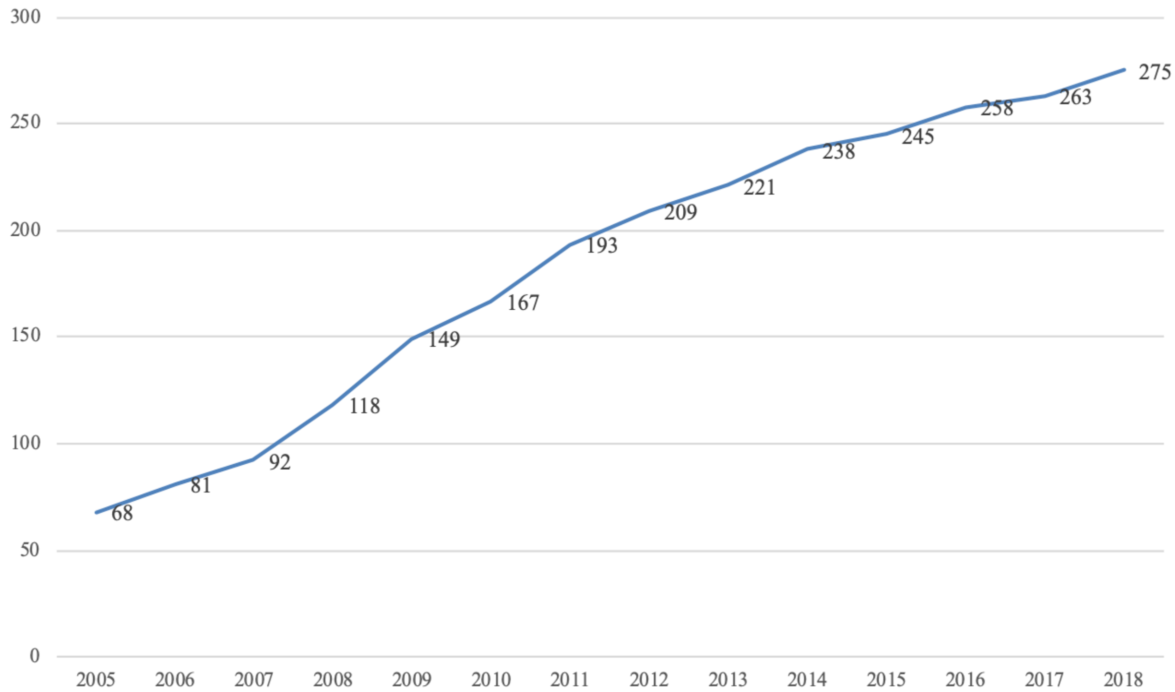


Figure 2-11 Change of the number of ICBFCs in Hiroshima Prefecture

Source: *MAFF*

2.3Methodology

As a geographical phenomenon, FLA is spatially autocorrelated and exhibits different temporal and spatial characteristics over time and space (Zhang et al., 2014). This study employs both qualitative and quantitative methods to analyze the data and research design can be divided into three stages (Figure 2-13). The first stage is literature review, which aims to clarify the research background and research designs. Second stage is quantitative stage, which focuses on statistical analysis and surveys to formulate a significant understanding of the determinants of FLA. Third stage is qualitative stage, which provides the interpretation and feedback of the statistical results.

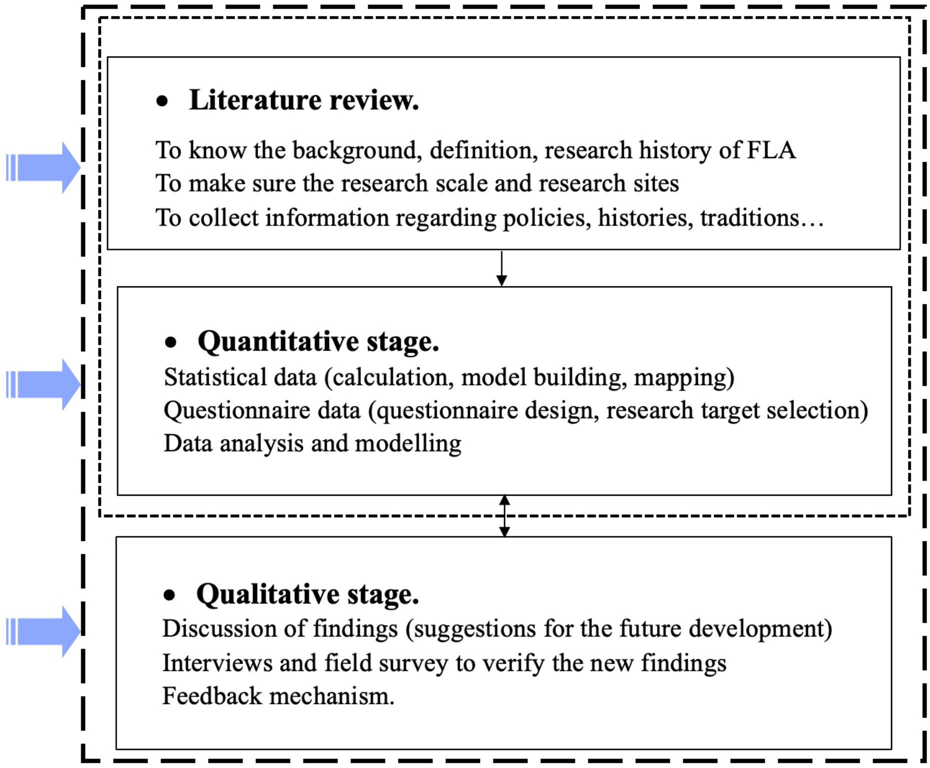


Figure 2-12 Research designs

For the qualitative analysis, literature review was conducted to know the trends and histories of studies on FLA. Secondly, field surveys were carried out, which includes questionnaire surveys and structured and semi-structured interviews. Such field surveys allow us to know the real local situations and provide rich information which cannot be cited from existing studies. Questionnaire surveys and interviews are necessary for understanding the issue of FLA from people's perspective.

Quantitative data processing and data analysis methods were employed to provide a comprehensive understanding of FLA, the individual statistical tests/tools are discussed in sections 2.3.1-2.3.4:

2.3.1 Multiple linear regression (MLR)

Multiple regression analysis is a highly flexible method for examining the relationship between independent variables and a dependent variable (Kemp, 2003). In reality, it is necessary to consider two or more influential factors as independent variables for explaining the changes in a dependent variable; this is what is meant by multiple regression. When the relationship between multiple independent variables and the dependent variable is linear, it is called multiple linear regression (MLR), which is also known as ordinary least squares and can be expressed as:

$$\hat{y}_i = \beta_0 + x_1\beta_1 + x_2\beta_2 + \cdots + x_i\beta_i + \varepsilon_i, \quad (2)$$

where i is the number of variables, β_i is the regression coefficient value, and ε_i is the random error. We use MLR in our research to find out the determinants of FLA from global regressions.

2.3.2 Geographically weighted regression (GWR)

Recently, the simple but powerful method of geographically weighted regression (GWR) has been widely used to explore continuously varying relationships at multiple scales. It can be applied in various fields, such as ecology, economy, land-use studies, social studies, and environmental studies (Tu, 2011). GWR estimates the parameter for each location (u_i, v_i) using a weighted least squares method, which can be expressed as:

$$\hat{y}_i = \beta_0(u_i, v_i) + \sum_{k=1}^{p} \beta_k(u_i, v_i)x_{ik} + \varepsilon_i, \quad (3)$$

where (u_i, v_i) represents the coordinate location of the observation i, $\beta_k(u_i, v_i)$ represents the regression parameters, and ε_i is the random error.

The weight matrix is expressed as $W_{(i)}$, and according to the principle of the weighted least squares method, the original parameter at location i is estimated as:

$$\hat{\beta}(i) = [X^T W(i) X]^{-1} X^T W(i) Y. \quad (4)$$

where

$$W_{(i)} =, \; X = \begin{bmatrix} 1 & x_{11} & \cdots & x_{p1} \\ 1 & x_{12} & \cdots & x_{p2} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{1n} & \cdots & x_{pn} \end{bmatrix}, \text{ and } \; Y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}.$$

GWR was employed to effectively visualize and identify how each determinant influences FLA and to describe local variations.

2.3.3 Principal component analysis (PCA)

PCA is a popular method used in many disciplines to describe patterns of variation within a multi-dimensional dataset and is one of the simplest and most robust ways of accomplishing dimensionality reduction (Abdi & Williams, 2010). PCA uses an orthogonal transformation to convert a number of potentially correlated variables into a set of uncorrelated variables called principal components (PCs). These components capture the variability in the original data (Abson et al., 2012; Uddin et al., 2019). The data capturing processes continue with additional PCs until all original data are fully captured (Teffera et al., 2018); the final number of PCs is determined based on eigenvalues (Zeinalzadeh & Rezaei, 2017). In the study, we use PCA to reduce the number of variables while providing the useful information of the original dataset. The PCs in the case describe the agricultural characteristics.

2.3.4 Local Moran’s I

There are two primary types of spatial autocorrelation that are relevant to regression analysis: global and local spatial autocorrelations. Anselin (1995) proposed local Moran’s I as a measure of local spatial autocorrelation to address the issue that global spatial autocorrelation cannot accurately quantify relationships in all parts of a study area in sufficient detail (Anselin, 1995). It is reasonable to assume that spatial patterns observed in closely spaced data are more likely to be similar than those that are further apart. Values of Moran’s I vary from −1 to 1, where a value near 1 indicates spatial clustering, while a value near −1 indicates spatial dispersion. Local Moran’s I was defined as:

$$Moran's\ I = \frac{n}{S}\frac{\sum_{j=1}^{n}\sum_{k=1}^{n} W_{jk}\left(x_j - \acute{X}\right)\left(x_k - \acute{X}\right)}{\sum_{j=1}^{n}\left(x_j - \acute{X}\right)^2}, \tag{5}$$

where n is the total number of municipalities, $\acute{X}$ is the mean of x, W_{jk} is the weight between cases j and k, and S is the sum of all W_{jk}:

$$S = \sum_{j=1}^{n}\sum_{k=1}^{n} W_{jk}$$

2.4Summary

This chapter has presented the research frameworks, study areas, data and methodologies. All the methodologies are combined and contribute to a better understanding of FLA at the three scales. The study adopted a mixed-methods approach, with qualitative and quantitative stages. Research design follows a sequential scale division, from the national, regional (intraregional) to local scales. The three scales provide rich information in terms of FLA and its mechanism. Results and explanations are not separated but complement each other in space and contents, and finally contributing to a comprehensive understanding of FLA in Japan.

For the data analysis, the author utilized the census data and questionnaire data from the three surveys. The census data were employed from the national and regional scales to explore the FLA at the macro scale. To fit with the features of the data, a variety of modeling approaches are applied to find the determinants of FLA. The questionnaire surveys emphasized the opinions of individual farm households and ICBFCs to investigate the FLA at the micro scale. The analyses and details of findings are further explained in chapter 3, 4 and 5.

CHAPTER 3 SPATIAL PATTERN AND DETERMINANTS OF FLA

The spatial pattern of land use and land cover change (LULCC) and its driving forces or drivers of landscape change has been evolving over the past two decades and has attained an indispensable position in LULCC research (Ye & Fang, 2011; Kanianska et al., 2014; Mallinis et al., 2014; Vinogradovs et al., 2018a). Through modifying structures and functions of terrestrial ecosystems, LULCC significantly affects ecosystems' goods and services for human needs, subsequently influencing sustainable development (Le, 2005). The rapid socio-economic and institutional changes may accelerate LULCC or shift land use to a new mode (Prishchepov et al., 2013). On the one hand, the transformation of land use and cover is a significant component for regional studies and for understanding the dynamics of environmental/socio-economic changes and human activities which may influence such transformation (Valbuena et al., 2010; Parcerisas et al., 2012). For sustainable utilization of the land ecosystems, it is essential to know the explicit spatial patterns of LULCC (Shoyama & Braimoh, 2011), extent, and location, as well as quality, productivity, suitability and limitations of various land uses (Sohel et al., 2011; Beilin et al., 2014). On the other hand, in addition to have a spatially explicit understanding of existing and predicted land cover changes, the knowledge of their underlying drivers is also important for future planning, managing land and sustainability (Etter et al., 2006; Baumann et al., 2011). Therefore, in this chapter, the spatial pattern and determinants of FLA in Japan are discussed.

Japan's agriculture is currently standing at the crossroads with the problems of aging and depopulation, rural deprivation (Okahashi, 1986), particularly in HAM areas (Shimizu, 2017). Thus, the future direction of Japanese agriculture is unclear for both farmers and the government. FLA, as a global issue, is accumulating in Japan, which became a big challenge for Japanese agriculture development. Different regions in Japan have experienced discrepancies regarding agriculture development and degrees of FLA. For regions with good agricultural condition such as Hokkaido, agriculture development is prosperous and with low level of FLA. In contrast, for regions where agriculture is facing many issues, agriculture is declining rapidly with increasing FLAR year by year. After outlying a national map of FLA, it is necessary to examine its regional differences which could have been induced by different driving forces during different periods in history and related political systems. And a close monitoring of land use by planners is necessary for prompt mitigation of the adverse effects of dramatic land change (Shoyama & Braimoh, 2011). To the author's knowledge, this is the first research that a national FLA map has been displayed. Additionally, local and global regression methodologies have been employed to explain FLA drivers at a national scale. The major objectives of this chapter are as follows:

(1) To identify the temporal and spatial patterns, and variations of FLA. The results can outline the spatial patterns and identify the clusters and low or high FLAR areas. Such results allow us to have an overview of FLA in Japan and to be aware of its trends;

(2) To explore how and to what extent, geographical and socio-economic determinants affect FLA by global regression. These findings are essential for understanding the roles of selected variables in FLA in Japan and the differences from other nations;

(3) To discuss the regional differences and spatial variations of determinants using local regression.

3.1 Temporal and Spatial Characteristics of FLA

3.1.1 Temporal characteristics of FLA

From Prefecture-wise, FLA exhibits some differences, however, the overall trend of FLAR is increasing. Table 3-1 clearly displays the FLAR in different Prefectures and their temporal variations from 2005 to 2015. At a national level, the FLAR increased from 9.66% to 12.14% over the 10-year period. In 2005, the highest value was observed in Nagasaki Prefecture with 27.13%; Yamanashi and Gunma Prefectures followed with values of 23.41% and 20.86%, respectively. In 2015, the highest FLAR was observed in Hiroshima Prefecture, i.e., 27.14%, followed by Yamanashi and Nagasaki Prefectures, with values of 26.85% and 26.72%, respectively. The FLAR in Hokkaido, Japan's most important agricultural region, was the lowest in all three years. Saga Prefecture witnessed the highest increase in the FLAR (8.39%), followed by Kagawa Prefecture with an increase of 8.34%. Only Okinawa and Nagasaki Prefectures experienced a slight reduction in terms of the change in the FLAR. Many Prefectures experienced a higher FLAR over time, which indicates that the scope of the impact of this issue is still broad.

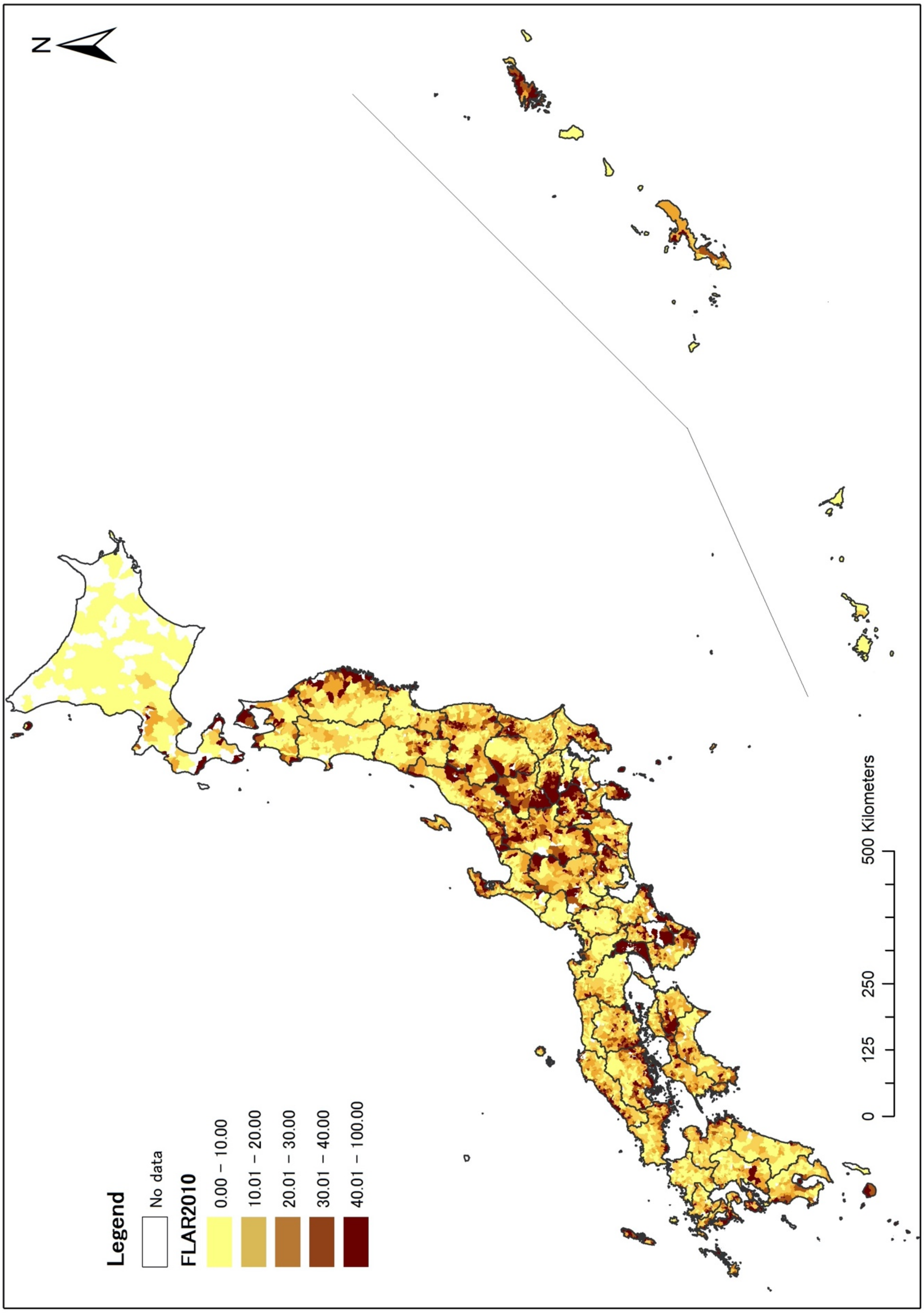
Table 3-1. FLARs in Japan by Prefecture, from 2005 to 2015.

Prefecture Name	FLAR 2005 (%)	FLAR 2010 (%)	FLAR 2015 (%)	2005–2015 Change (%)	Prefecture Name	FLAR 2005 (%)	FLAR 2010 (%)	FLAR 2015 (%)	2005–2015 Change (%)
Hokkaido	1.97	1.84	2.03	0.05	Shiga	4.29	4.91	6.20	1.92
Aomori	11.73	12.76	15.54	3.82	Kyoto	9.85	11.23	13.36	3.51
Iwate	9.68	12.01	15.97	6.29	Osaka	14.74	15.04	16.50	1.76
Miyagi	7.25	9.15	12.25	5.00	Hyogo	7.80	9.27	12.03	4.22
Akita	5.06	6.05	8.16	3.10	Nara	18.50	19.04	21.19	2.69
Yamagata	6.04	7.67	8.79	2.75	Wakayama	12.11	14.29	16.80	4.70
Fukushima	14.91	15.67	20.40	5.49	Tottori	11.15	12.51	14.57	3.42
Ibaraki	13.70	14.70	17.51	3.82	Shimane	18.39	20.40	24.09	5.70
Tochigi	7.39	7.93	9.77	2.39	Okayama	16.89	18.60	21.14	4.25
Gunma	20.86	22.07	24.19	3.33	Hiroshima	20.33	23.26	27.14	6.81
Saitama	16.49	17.42	19.23	2.74	Yamaguchi	17.31	20.71	25.12	7.80
Chiba	15.47	16.61	19.12	3.64	Tokushima	15.90	16.63	18.81	2.91
Tokyo	14.80	14.54	16.28	1.47	Kagawa	15.31	18.64	23.65	8.34
Kanagawa	14.33	15.03	16.24	1.90	Ehime	19.15	21.95	24.65	5.50
Niigata	5.88	6.46	7.69	1.81	Kochi	15.68	16.67	18.38	2.69
Toyama	4.64	5.72	7.68	3.04	Fukuoka	8.86	10.64	11.30	2.44
Ishikawa	15.35	17.31	18.75	3.39	Saga	8.48	15.28	16.87	8.39
Fukui	4.67	5.94	7.49	2.82	Nagasaki	27.13	25.95	26.72	−0.41
Yamanashi	23.41	24.51	26.85	3.44	Kumamoto	11.94	13.43	14.72	2.78
Nagano	17.46	18.74	19.74	2.27	Oita	16.15	17.84	19.91	3.76
Gifu	11.56	12.66	16.39	4.83	Miyazaki	8.31	8.58	10.19	1.88
Shizuoka	18.52	20.29	22.60	4.08	Kagoshima	12.65	12.69	13.29	0.65
Aichi	13.28	13.06	14.87	1.59	Okinawa	10.89	10.54	9.35	−1.54
Mie	12.97	13.94	16.45	3.49	National	9.66	10.56	12.14	2.48

Source: *Ministry of Agriculture, Forestry and Fishery (MAFF), http://www.maff.go.jp/e/index.html.*

3.1.2 Spatial patterns of FLA

Besides its temporal characteristics, its spatial patterns also help to understand the development of FLA in the study region. FLA was distributed in an uneven pattern over the seven regions in Japan. Figure 3-1 (a-b) shows the FLARs and their spatial distribution in 2010 and 2015. In Hokkaido, farmland remained stable, and only a few areas experienced a FLAR higher than 40%. In the Tohoku, Kinki and Kyushu regions, the situation was also less serious than in some other high-elevation regions. In the Tohoku region, the area with a high FLAR was mainly distributed along the eastern coastal region. In the Kinki region, northern Kinki had a very low FLAR, while southern Kinki showed a different pattern, with many high FLAR areas. The Chugoku Shikoku, Kanto, Kyushu, and Chubu regions exhibited a serious situation of abandonment, with many high FLAR areas. In the Chugoku Shikoku region, FLA tended to be severe in coastal areas and on small isolated islands in Seto Inland Sea. This was very similar to the Kyushu region, where abandoned farmland was predominantly located in western coastal island areas in Nagasaki and Kumamoto Prefectures. In the Kanto region, abandoned farmland had a distinct radial distribution with the Tokyo metropolitan area at the center. Abandoned farmland was dominantly distributed around the peripheral areas of the Kanto region, especially in northwestern regions of the Ibaraki, Gunma, and Saitama Prefectures. The Chubu region is under the influence of the Japanese Alps and has many high FLAR areas. Compared with the data from 2010, the abandoned area in 2015 (Figure 3-1 (c)) exhibited an increase (>50 ha) in Kanto, north of Tohoku, Hokkaido, and part of the Chugoku/Shikoku regions, but exhibited a decrease (<50 ha) mainly in northern Chubu in Niigata Prefecture and Tohoku region because of the good farmland conditions to secure a stable agriculture development. In this study, data from 2005 and before were not compatible with those from 2010 and 2015 because of the change in the municipality codes. Future research can investigate longer time phases for this trend as well as simulations and predictions of future FLA. For detailed information of FLAR and FLA areas in 7 regions, refer to Appendix I-VII.


N
Legend
No data
FLAR2010
0.00 – 10.00
10.01 – 20.00
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30.01 – 40.00
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0
125
250
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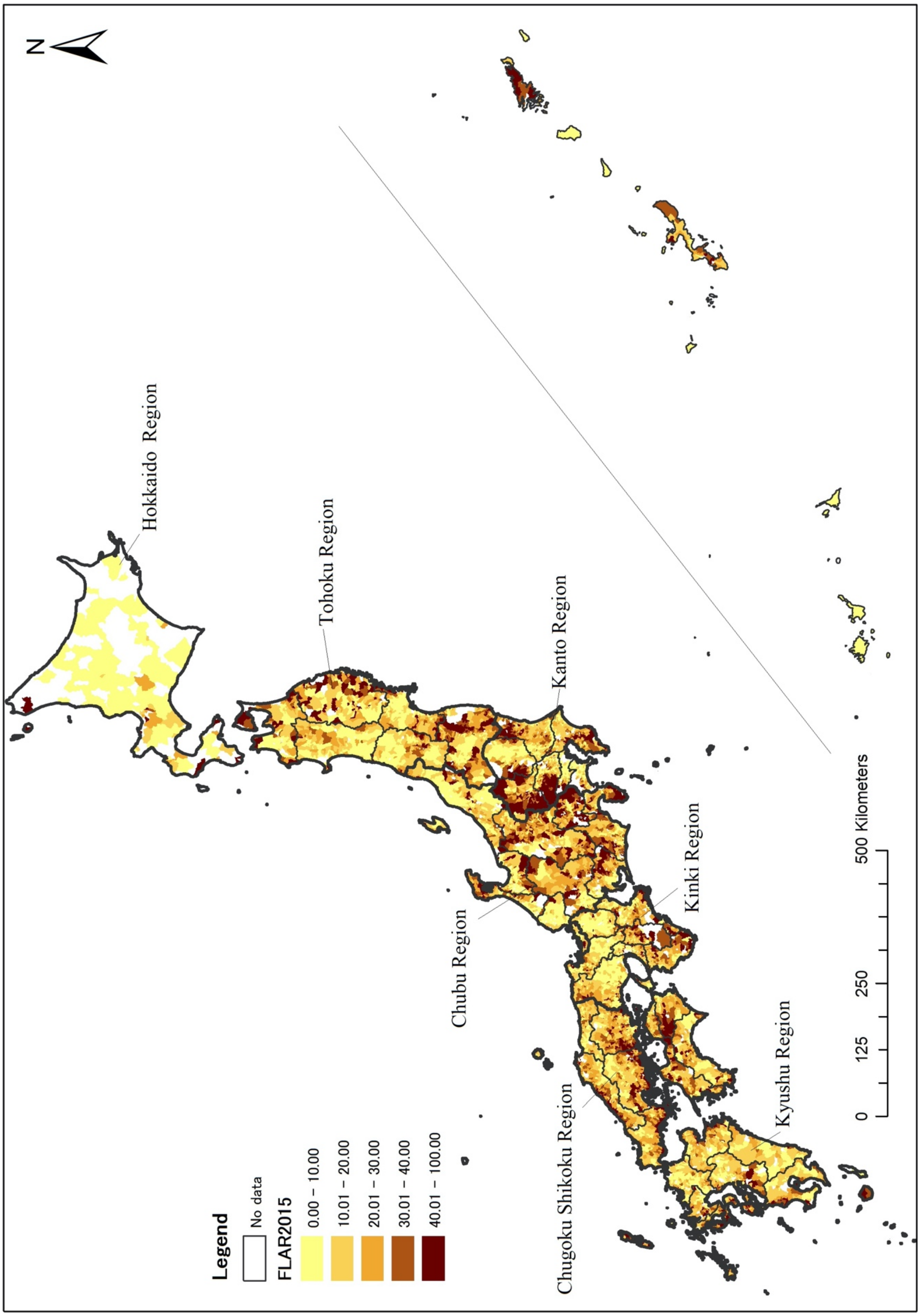
(a)


N
Hokkaido Region
Tohoku Region
Kanto Region
Kinki Region
Chubu Region
Chugoku Shikoku Region
Kyushu Region
Legend
No data
FLAR2015
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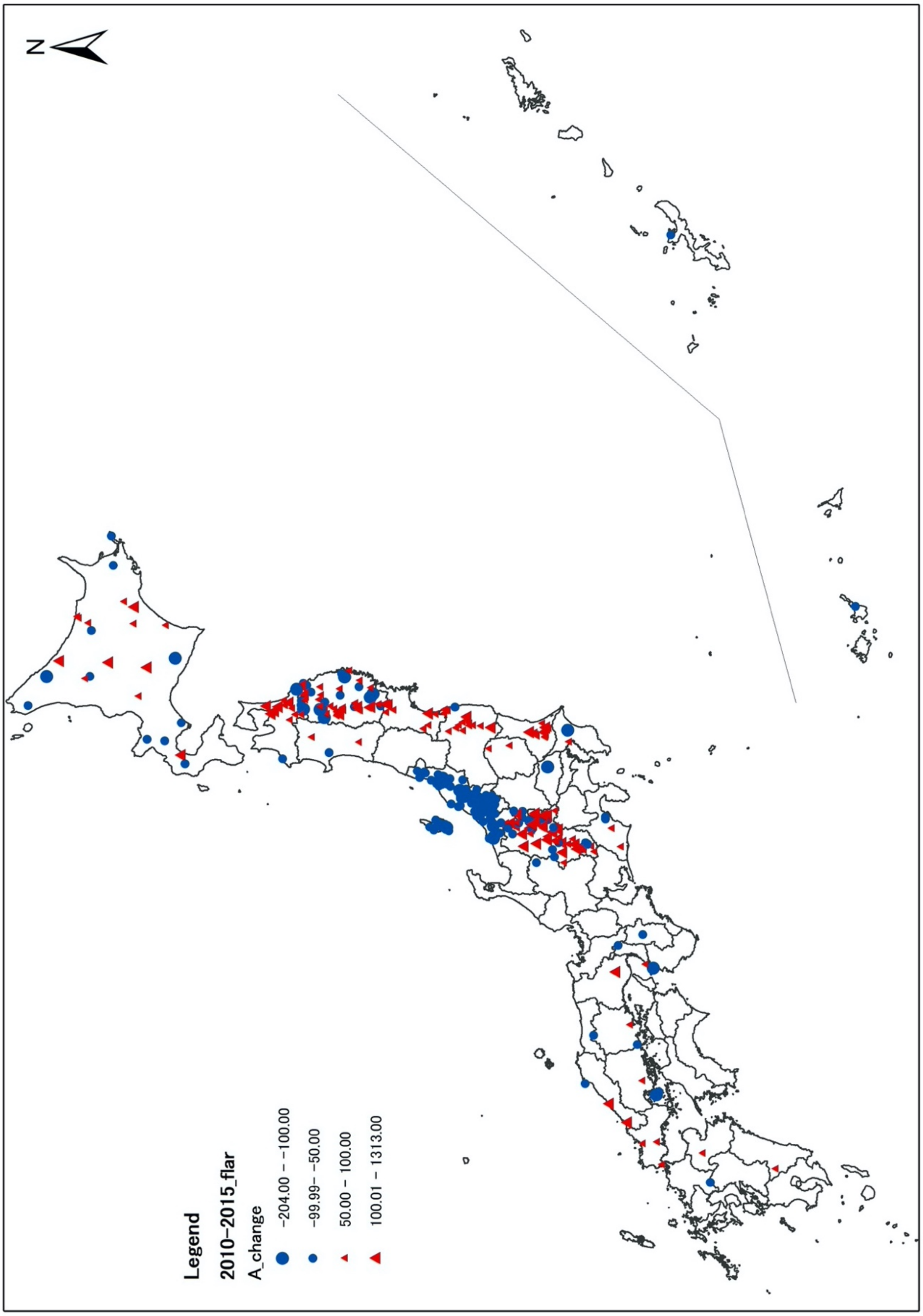
10.01 – 20.00
20.01 – 30.00
30.01 – 40.00
40.01 – 100.00
0 125 250 500 Kilometers

(b)



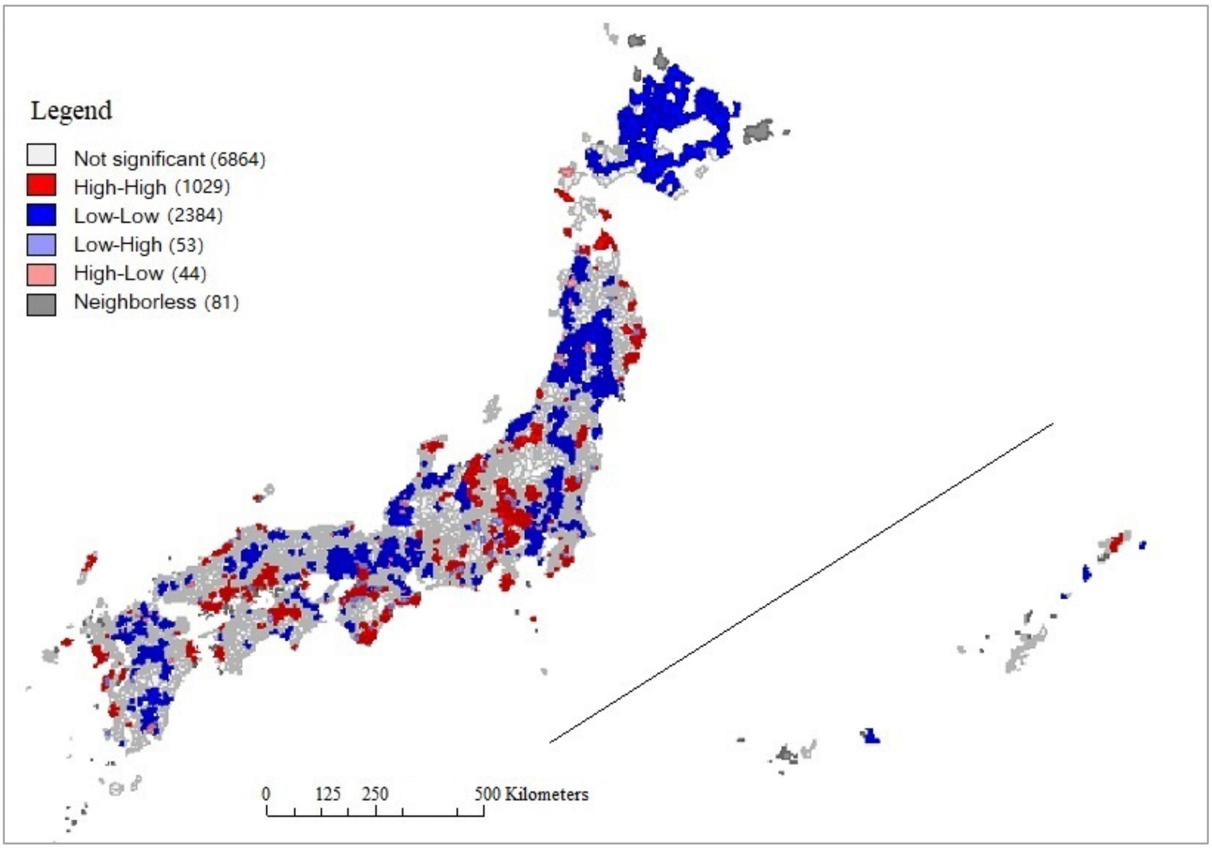
(c)

Figure 3-1 (a) FLAR in Japan in 2010; (b) FLAR in Japan in 2015; (c) Changes in farmland abandoned areas (ha)

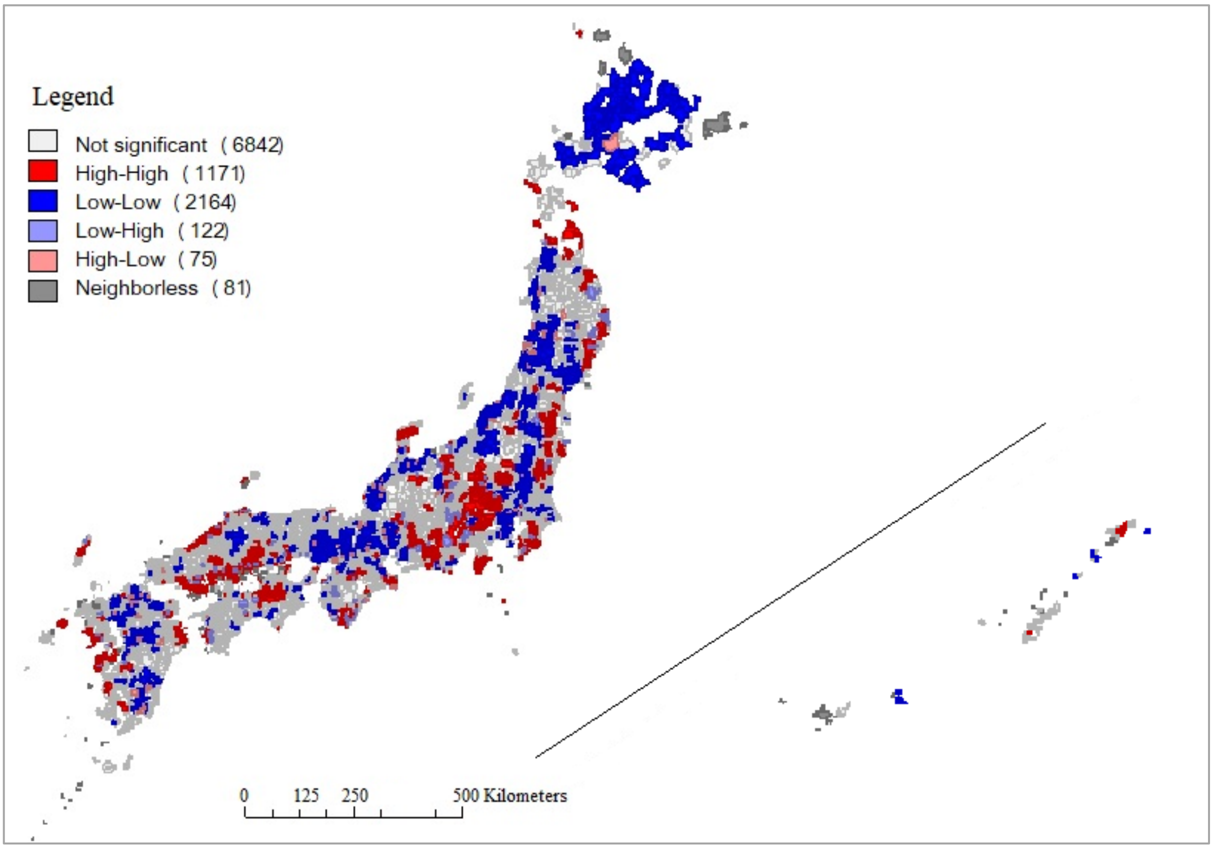
Source: *MAFF.*

3.1.3 Spatial autocorrelations

To visualize the spatial features of FLA in 2010 and 2015, we calculated Moran's I and outlined local indicators of spatial association (LISA) statistics to present data non-stationarity or hot/cold spots of FLA (Anselin, 1995; Ord & Getis, 1995). Moran's I indices of FLAR were 0.669 for 2010 and 0.554 for 2015, both of which were significant at the $p<0.001$ level. Results indicated that FLA in Japan is positively spatial-clustered, although the level of FLAR has decreased. With respect to LISA statistics, high-high agglomeration municipalities or hot spots were chiefly distributed in the western Kanto region, Chubu region, southern Kinki region, coastal areas of the Chugoku Shikoku region and the Kyushu region. Low-low agglomeration municipalities or cold spots were mostly located in the Hokkaido, Tohoku, and northern Kinki regions in 2010 (Figure 3-2(a)). By 2015 (Figure 3-2(b)), the number of high-high agglomeration municipalities increased from 1029 to 1171, and low-low agglomeration municipalities decreased from 2384 to 2164, indicating that the trend of FLA increased from 2010 to 2015. Low-high and high-low agglomeration municipalities displayed a scattered distribution in both periods.



(a)



(b)

Figure 3-2 Spatial autocorrelation of the FLAR in Japan for 2010 and 2015 (a) 2010; (b) 2015.

Source: *Author.*

3.2 Determinants and Regional Variations of FLA

3.2.1 The major determinants of FLA in Japan

As stated in the introduction, determinants of FLA are usually assessed by different scholars into environmental (natural) and socio-economic aspects (Rey Benayas, 2007). This study also followed this classification and selected most of variables based on theories and previous studies.

Of the Geographical variables tested, mean slope positively correlated with FLA. For socio-economic variables, household-related variables such as arable land ratio of self-sufficient farm households had the most significant (positive) impact on FLA. Ratio of non-successor farm households and laborers per farm household also positively affected abandonment, and the impacts were significant at the 0.01 level. In contrast, arable land area per household had a negative effect on FLA. For farmland-related variables, paddy field density had a significant negative impact on abandonment (Table 3-2).

Prior to regression analysis, Pearson's test was carried out to confirm the presence or absence of preliminary co-linearity among variables. The author confirmed that there was no significant co-linearity among the explanatory variables; the correlation coefficients did not exceed the threshold value of 0.75 (Clement et al., 2009) (Appendix VIII).

For the regression, the author developed four models and ran MLR and GWR simultaneously to examine their correlations with FLA and to identify the best-fit model. In model 1, the author included all the variables for MLR. The results indicated that this model explained approximately 47.5% of determinants regarding FLA. There was a significant difference in the coefficients among selected variables. In model 2, all geographical variables were introduced. This model explained approximately 14.7% of determinants regarding FLA, with slope having a more significant effect than road density. Model 3 explained approximately 44.7% of determinants regarding abandonment, with all socio-economic variables being considered. The arable land ratio of self-sufficient farm households had the most significant explanatory ability. Model 4 explained approximately 48.9% of determinants and was the best-fit model considering overall performance as well as the stability of coefficients of each variable. This indicates that FLA in Japan is influenced by the arable land ratio of self-sufficient farm households, the ratio of non-successor farm households, paddy field density, mean slope, arable land area per farm household and laborers per farm household.

From MLR results, the correlation between dependent and independent variables has been displayed. The results (Table 3-2) indicated that the best model (Model 4) could identify approximately half (with a R_{adj}^2 value of 0.489) of the reasons for FLA in Japan. Geographical variables, such as mean slope, were positively correlated with FLA. For socio-economic variables, household-related variables, such as the arable land ratio of self-sufficient farm households, had the most significantly positive impact on FLA. The ratio of non-successor farm households also positively affected abandonment and was significant at the 0.01 level. In contrast, arable land area per farm household and laborers per farm household had negative effects on FLA. Furthermore, for farmland-related variables, paddy field density had the most significant negative impact on abandonment. However, MLR only revealed a statistical relationship between dependent variables and independent variables. To explore the influence of each specific variable considering its spatial variations, the GWR will be further introduced.

Table 3-2. Model selection and the best-fit model

Variables			**Model 1**	**Model 2**	**Model 3**	**Model 4**
Geographical variables		X1 mean slope	0.150 **	0.386 **		0.158 **
		X2 expressway density	−0.044 **	0.002		
		X3 railroad density	0.011	0.035 **		
Socio-economic variables	Household-related	X4 arable land ratio of self-sufficient farm households	0.433 **		0.452 **	0.457 **
		X5 arable land ratio of land tenure non-farm households	0.029 **		0.016	
		X6 arable land area per farm household	−0.119 **		−0.117 **	−0.116 **
		X7 ratio of the first type of part-time farm households	−0.006		−0.014	
		X8 laborers per farm household	−0.073 **		−0.115 **	−0.065 **
		X9 ratio of non-successor farm households	0.145 **		0.174 **	0.147 **
	Farmland-related	X10 ratio of leased (tenanted) land	−0.036 **		−0.031 *	
		X11 ratio of leased-out land	0.027 *		0.007	
		X12 paddy field density	−0.237 **		−0.265 **	−0.222 **
AICC(MLR)			52,171.98	57,092.23	52,466.74	52,203.11
AICC(GWR)			51,142.31	55,795.29	50,815.72	50,399.48
R_{adj}^2 (MLR)			0.469	0.147	0.447	0.489
R_{adj}^2 (GWR)			0.594	0.198	0.617	0.637

**. Correlation is significant at the 0.01 level (2-tailed);

*. Correlation is significant at the 0.05 level (2-tailed).

3.2.2 Regional differences of FLA

In contrast to global regression, local regression allows the analyst to assess the local spatial cause-and-effect relationships that might exist between the dependent and independent variables (Clement et al., 2009). In addition, the regression coefficients are not static, but vary spatially across the study region (Brunsdon et al., 1999), and the model performance is superior in its fitting ability when considering spatial relationships (Oliveira et al., 2014). In this study, FLA is regarded as a process of the human–environment interaction. Therefore, GWR was employed to effectively visualize and identify how each determinant influences FLA and to describe local variations.

Before applying GWR, local Moran's I was calculated. Table 3-3 displays the Moran's I values and their significance based on the Z-score and p-value for each variable. The results indicated a significant spatial autocorrelation, with spatial clustering among the variables. A fixed kernel bandwidth was found to perform in a superior way because of the large sample size, and, therefore, it was adopted to reflect the relationships among different data samples. The R_{adj}^2 values were significantly improved from 0.489 to 0.637, and the corrected Akaike Information Criterion (AICC: used to measure the goodness of fit for a model.) decreased from 52203.11 to 50399.48 in the best model. This indicated that GWR performed better than MLR in terms of AICC and R_{adj}^2, which corroborates other empirical finding (Pineda Jaimes et al., 2010; Chiou et al., 2015).

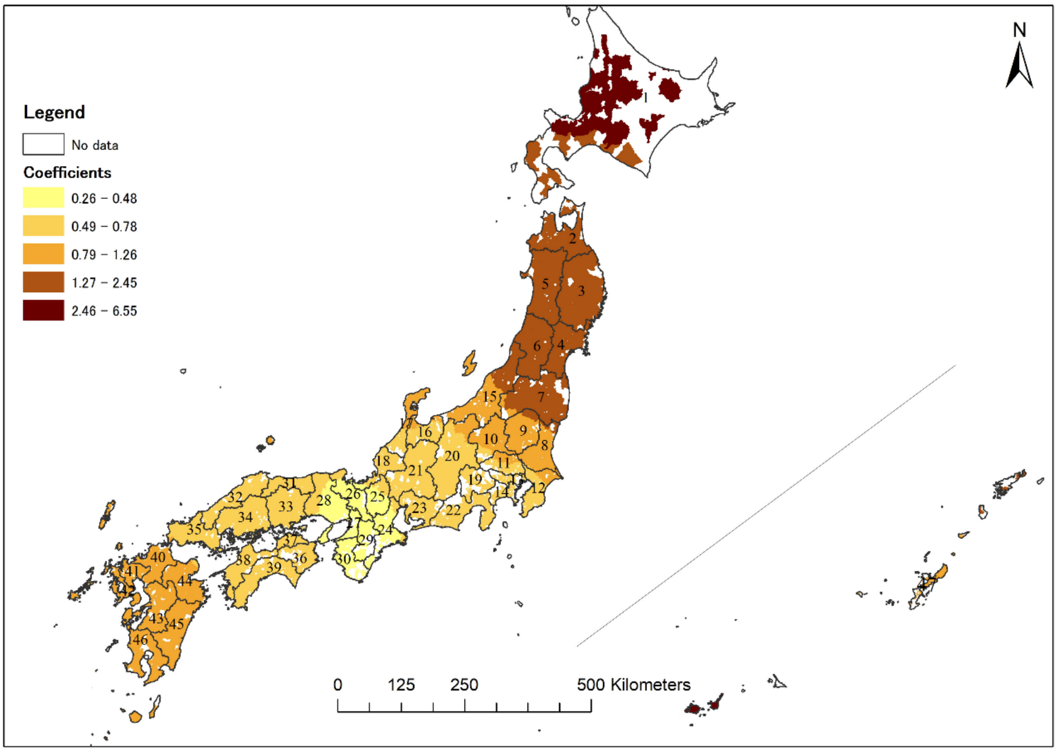
Table 3-3. Moran's I statistics of the dependent and selected independent variables

Variable		**Moran's I**	**Z-Score**	***p*-Value**	**Coefficients**
Dependent variable	Y FLAR	0.554	86.43	0.001	
Independent variables	X1 mean slope	0.790	126.72	0.001	0.158 **
	X4 arable land ratio of self-sufficient farm households	0.541	84.62	0.001	0.457 **
	X5 arable land area per farm household	0.773	118.68	0.001	−0.116 **
	X8 laborers per farm household	0.617	94.14	0.001	−0.065 **
	X9 ratio of non-successor farm households	0.315	45.55	0.001	0.147 **
	X12 paddy field density	0.695	103.54	0.001	−0.222 **

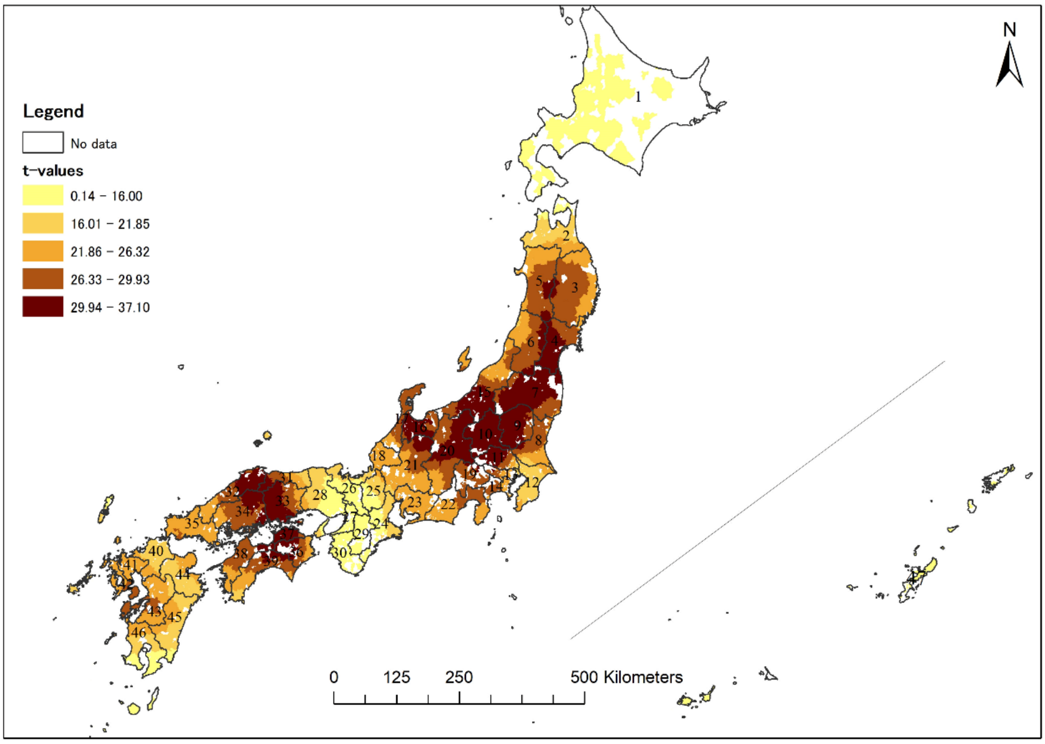
**. Correlation is significant at the 0.01 level (2-tailed);

*. Correlation is significant at the 0.05 level (2-tailed).

The author retained one variable in each GWR and plotted the results to display the spatial variances of determinants (Figures 3-3,8). Locally weighted coefficients and pseudo *t* values were visualized to represent the contribution and fitting level for each GWR. The arable land ratio of self-sufficient farm households exhibited a positive correlation with abandonment at national scale (Figure 3-3a). The correlation was significant in the northern Chubu, northern Kanto, southern Tohoku, and central Chugoku/Shikoku regions (Figure 3-3b). Such result indicates that the ratio of self-sufficient farm households in these regions is more likely to affect FLA. Paddy field density of coverage displayed a negative correlation in most regions (Figure 3-4a), but a significant correlation was not observed in the southern Kyushu, southern Kinki and southern Kanto regions (Figure 3-4b). This result may be ascribed to the low share of rice production. In comparison to other regions, these are upland cropping areas and are famous for fruit orchards, and vegetables and tea production, and so the density of rice paddy fields is relatively low as this is not a mainstay of agriculture. All regions displayed a significant positive correlation of the slope with the FLAR, except Hokkaido (Figures 3-5a, b), because Hokkaido has many plain fields and has a stable agricultural condition, while other regions are more or less affected by terrain condition. The ratio of non-successor farm households displayed a positive correlation in all regions except Hokkaido (Figure 3-6a), with the most significant effect in the Chugoku, southern Kinki, and Chubu regions (Figure 3-6b). There are many un-favored rural areas in southern Kinki, and Chugoku, while Chubu is under the influence of the Japanese Alps. Young generations in those regions migrated to cities and refused to engage in agriculture. The existence, or not, of successors has become a vital determinant of FLA in Japan. Arable land area per farm household was negatively correlated with FLA at national scale, with the highest and the most significant correlation in the Chugoku region (Figures 3-7 a,b), where farmland occurred in fragmented plots and on a small scale, which readily resulted in abandonment due to the difficulty of maintenance (Deininger et al., 2012). The number of laborers per farm household exhibited a negative correlation in most regions, while displaying the most significant positive correlation with FLA in Chugoku (Figures 3-8 a,b), which caused biases, and was beyond the expectations. Considering that the labor variable was calculated from commercial households, and because of the low share of commercial households in Chugoku, the labor condition may not represent the whole region. This could be one of the limitations of the study when calculating variables based on one type of household, due to data availability and their spatial variations. Future analysis is necessary to discuss the labor condition by considering total farm households.

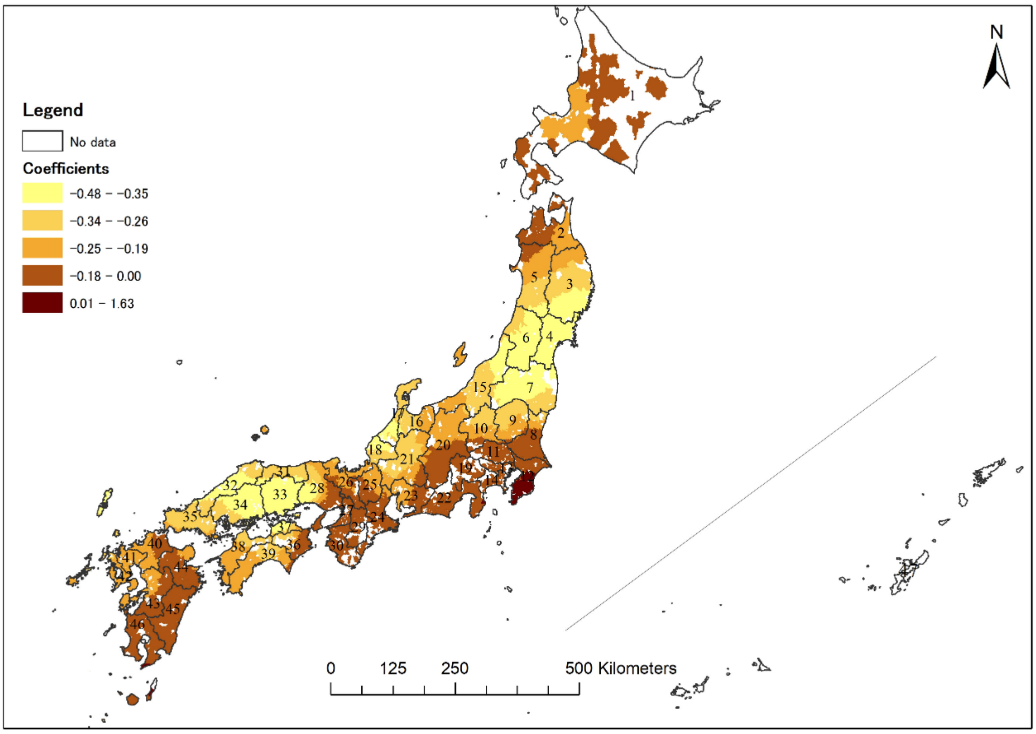


(**a**) Coefficients

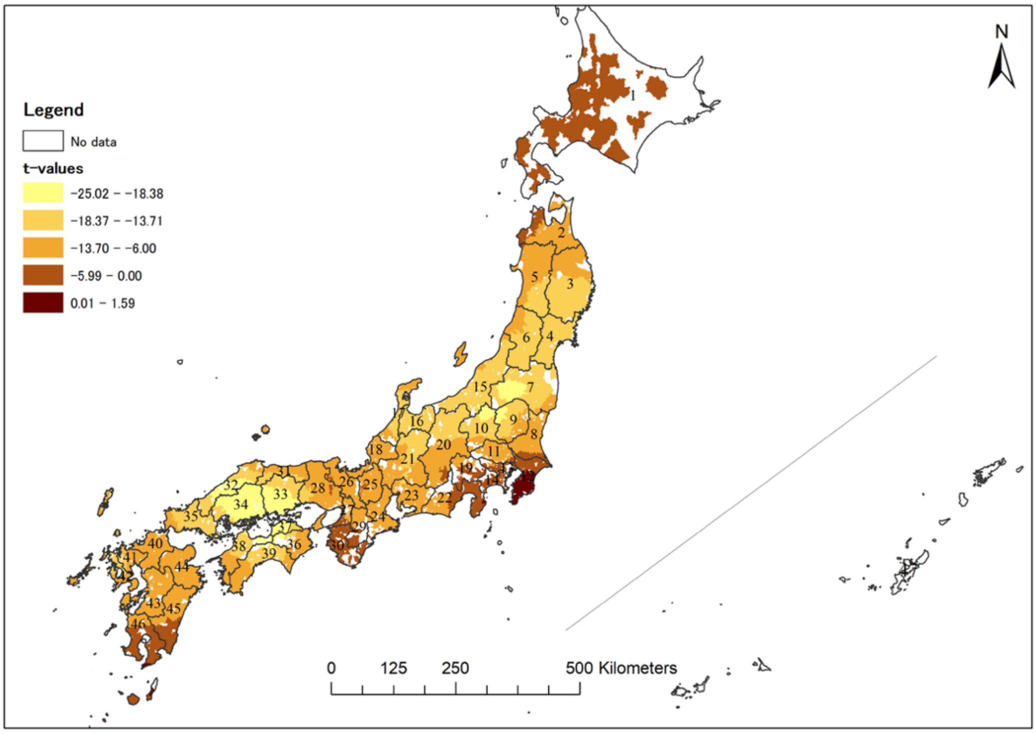


(**b**) t-values

Figure 3-3 Spatial distribution of estimated coefficients and pseudo t-values of the arable land ratio of self-sufficient farm households

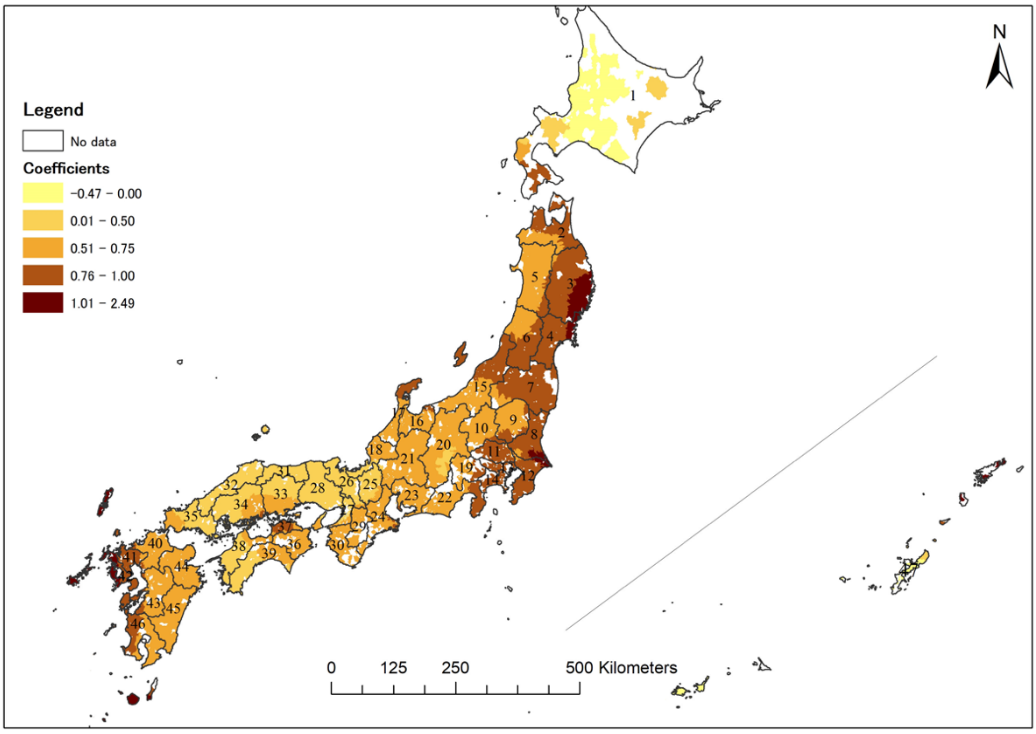


(**a**) Coefficients

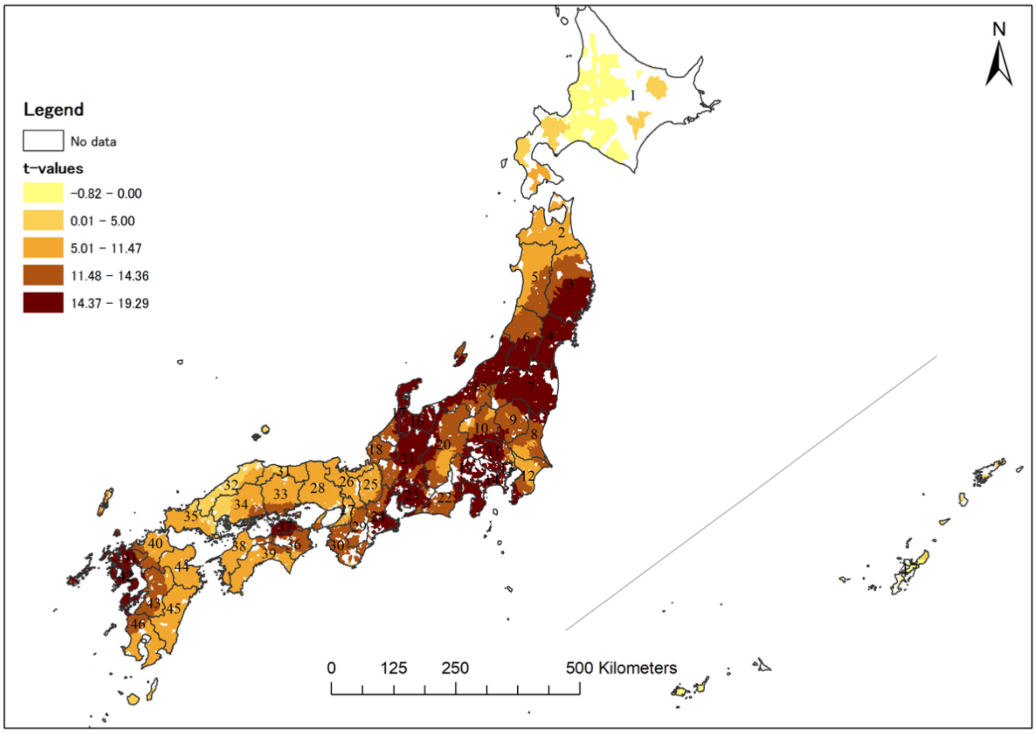


(**b**) t-values

Figure 3-4 Spatial distribution of estimated coefficients and pseudo t-values of paddy field density

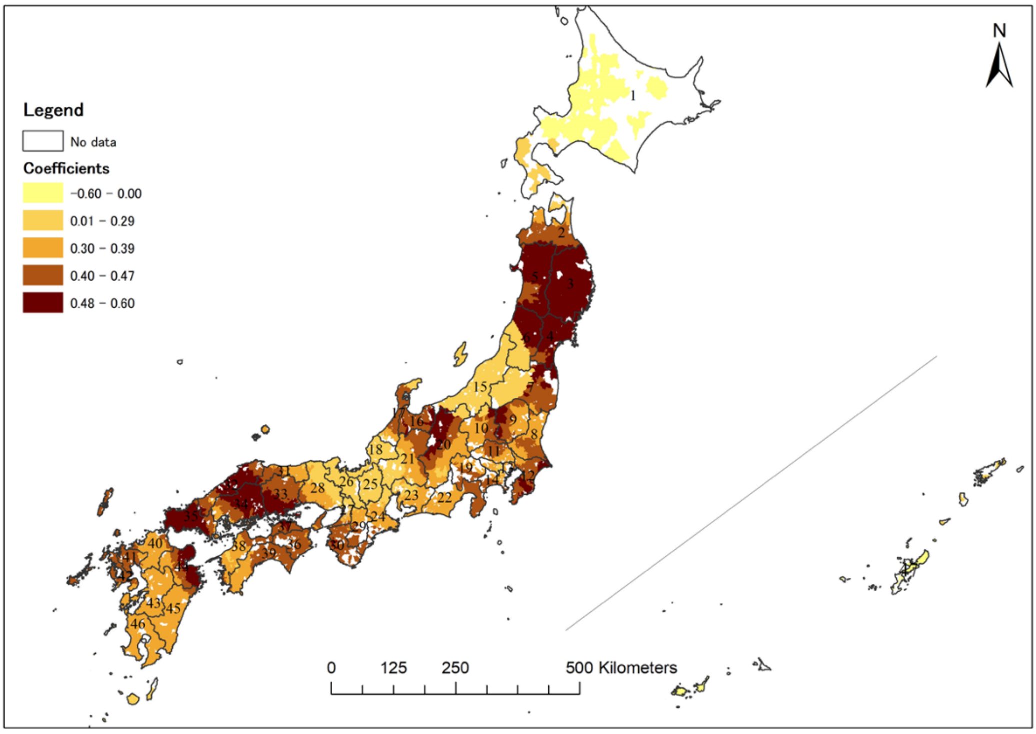


(**a**) Coefficients

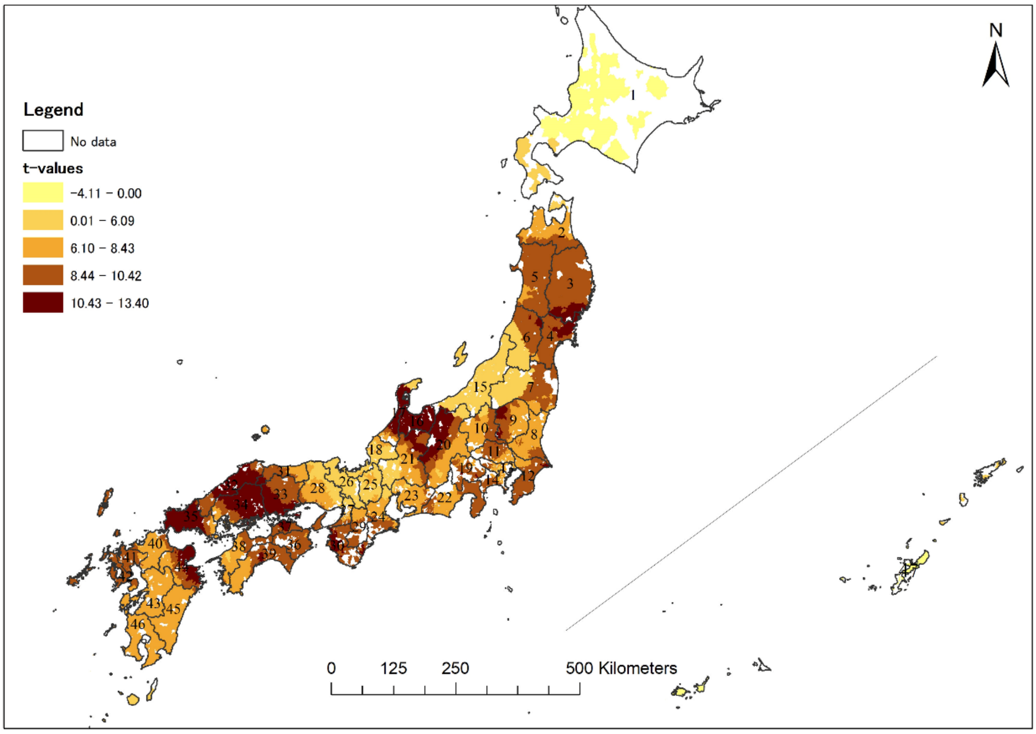


(**b**) t-values

Figure 3-5 Spatial distribution of estimated coefficients and pseudo t-values of the mean slope

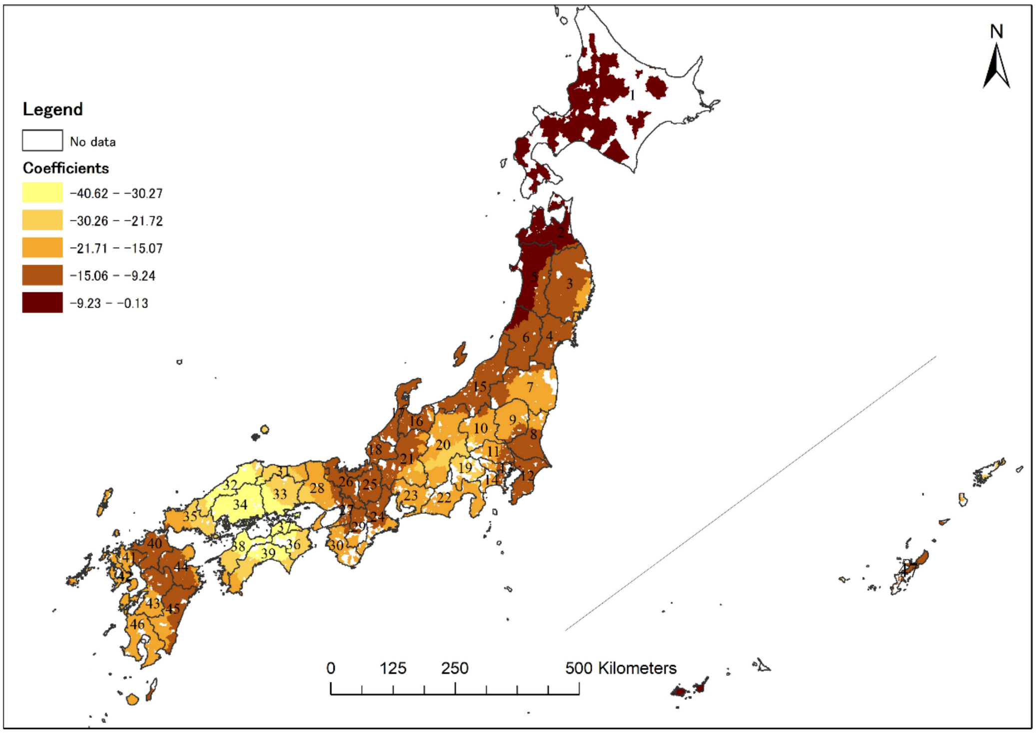


(**a**) Coefficients

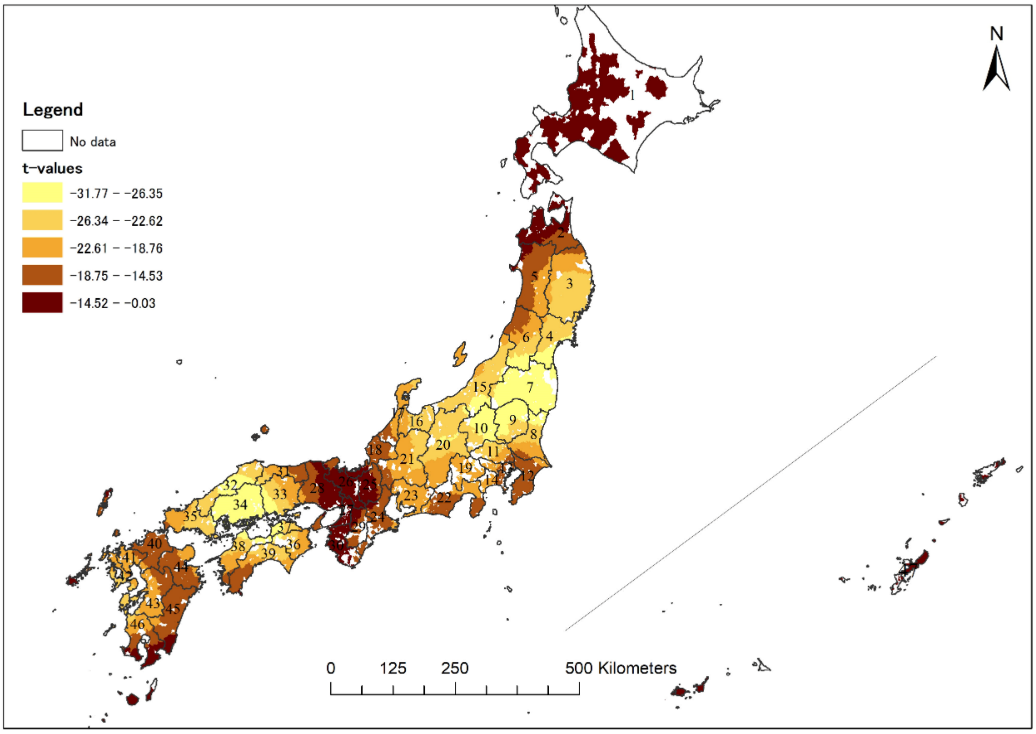


(**b**) t-values

Figure 3-6 Spatial distribution of estimated coefficients and pseudo t-values of the ratio of non-successor farm households

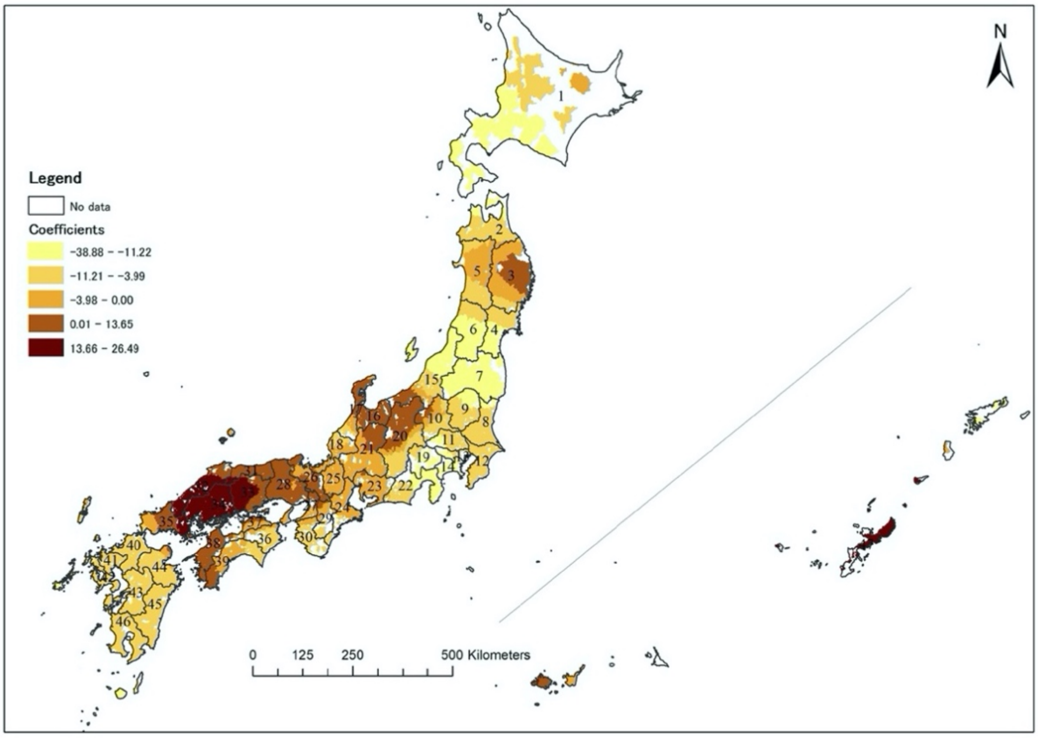


(**a**) Coefficients

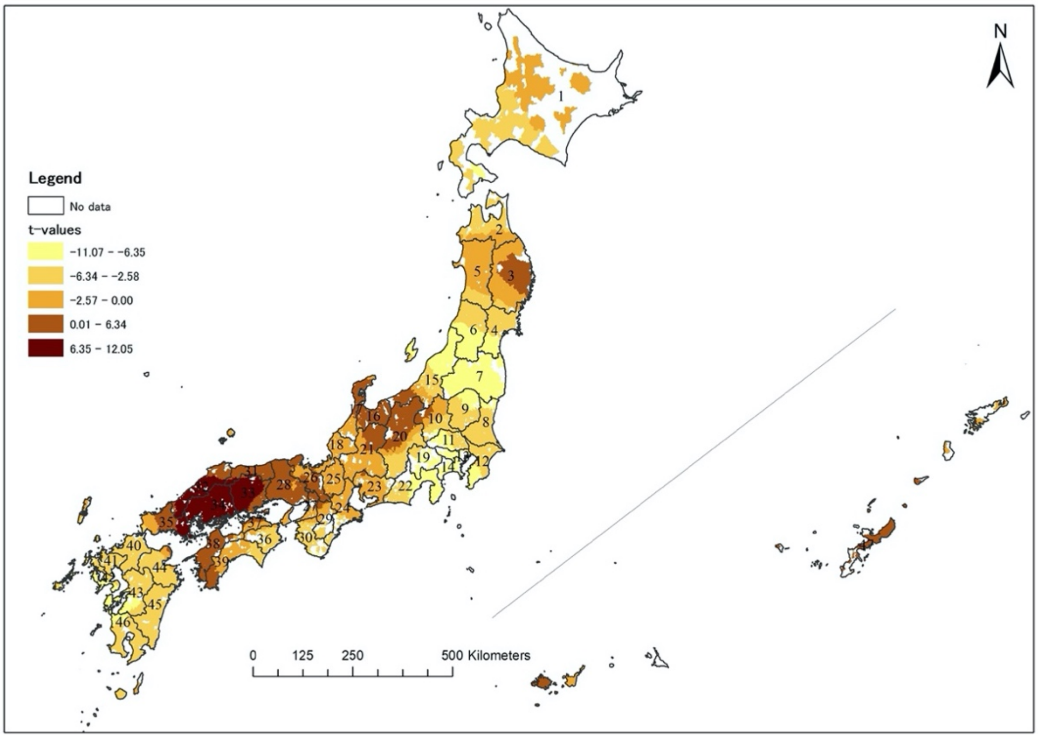


(**b**) t-values

Figure 3-7 Spatial distribution of estimated coefficients and pseudo t-values of arable land area per farm household



(**a**) Coefficients



(**b**) t-values

Figure 3-8 Spatial distribution of estimated coefficients and pseudo t-values of laborers per farm household

3.3 How to Explain the FLA in Japan

In recent years, FLA has become a serious issue in Japan, which reflects agricultural loss as well as depopulation and the aging society especially in rural areas. However, for a better understanding of this issue, the regional characteristics and determinants need to be explored further. This chapter employs MLR and GWR, which focused on different perspectives, to investigate FLA. The findings can provide an explicit explanation of the spatial characteristics as well as the determinants of FLA.

3.3.1 The uneven pattern of FLA in seven regions

Based on the results, spatial patterns of FLA in Japan were uneven, and different regions shared different extents of FLA, which strongly corresponded to regional geographical conditions and agricultural development. Compared with the national level and considering their spatial patterns, the author divided the seven regions into three categories: low abandonment, moderate abandonment, and high abandonment. Among these, Hokkaido lagged behind the national level and had low abandonment (Figure 3-9). Here, farmers overcome harsh geographical conditions, develop agriculture sustainably, and also possess different agricultural development paths and land tenure compared with other regions (Ito et al., 2016). The Tohoku region and Kinki region had moderate abandonment, while most of the low-low abandonment agglomerations or cold spots (Figure 3-2) and the FLAR were similar to those of the national level. Agriculture in Tohoku is typically well maintained and is famous for monocropping of rice. In addition, farm households have strong kinship ties and many young generations assist their elder parents to do agriculture (Shoji, 2015). In GWR, paddy field density and ratio of non-successor farm households also exhibited strong correlation associated with FLAR in Tohoku (Figures 3-4 and 3-6). Northern Kinki has a good farmland condition, while southern Kinki is a mountainous area, and agriculture is experiencing challenges in cases of fruit, vegetable and tea production. On the eastern coast of Tohoku, the FLAR varied greatly from 2010 to 2015 (Figure 3-1(a)). Meteorological factors play a key role in coastal areas due to the extreme weather conditions throughout the years, such as monsoon and seasonal currents, which adversely affect agriculture. The Chugoku Shikoku, Kanto, Kyushu and Chubu regions exhibited high abandonment levels, which were obviously higher than the national level (Figure 3-9). In these regions, most of the areas had a high FLAR, along with high-high agglomerations or hot spots (Figures 3-2(a,b)). Farmland in the Kanto and Chubu regions is constrained, either from the high elevation under the Japanese alps or urbanization in association with the out-migration of laborers to metropolises (Yokomichi, 2007). In the

Chugoku Shikoku region, rural depopulation first occurred in mountain zones, along with serious aging and issues associated with a lack of agricultural successors (Kanzaka, 2009). Many plots in coastal areas were previously used for orange production, but from 2010, due to low yields, farmers abandoned their orange fields, which contributed significantly to the increase in the FLAR without any mitigation until now.

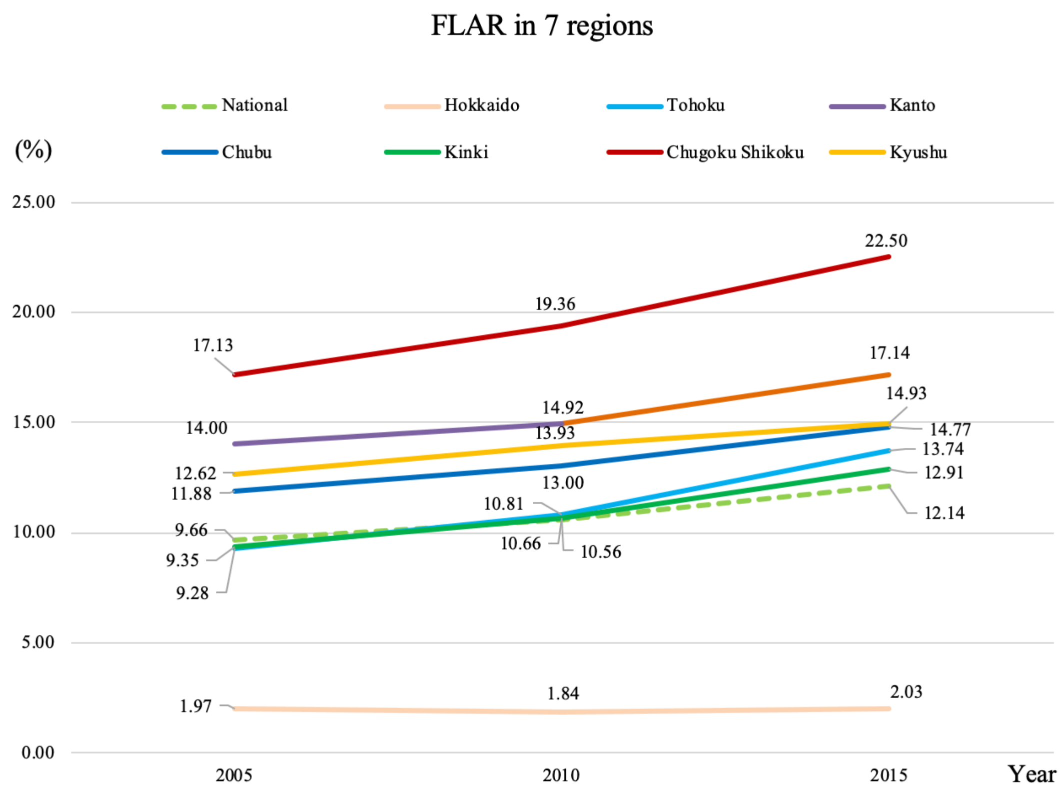


Figure 3-9 FLA in seven regions from 2005 to 2015

Source: *MAFF.*

3.3.2 Determinants of FLA

The combination of global and local regression in interpreting determinants of FLA in Japan generates a comprehensive understanding. Based on the global regression, geographic variables, such as slope, demonstrated a significantly positive correlation with FLA, which has already been reported in previous studies (MacDonald et al., 2000; Díaz et al., 2011; Müller et al., 2013; Gellrich et al., 2007). In Japan, soil condition may also relate to regional abandonment. There are cases farmers transport soils (known as soil dressing or *Kyakudo* in Japanese) from the higher mountains or other places to enrich the fertility of their paddy fields. In contrast, expressway and railroad densities did not exhibit a significant correlation.

Agricultural production in Japan is highly mechanized in the face of laborer supply shortages, and so farmers are more concerned about the availability of agricultural machines than road conditions, which are well maintained in rural Japan. Socio-economic variables, such as successors of farm households and laborers per farm household determine abandonment, which is similar to previous results (Díaz et al., 2011; E. Corbelle-Rico et al., 2012; Pazúr et al., 2014; Terres et al., 2015; Zhang et al., 2014; Heller, 2016; Shoji, 2015; Gibon et al., 2010). However, the significance of variables such as the arable land ratio of self-sufficient farm households, arable area per household and paddy field density are interesting and unique in a Japanese context. The above conclusions were only drawn from the perspective of global regression. In regard to GWR, Hokkaido had a low FLAR, and it exhibited an obviously different pattern compared with other regions. In addition, the author found discrepancies in the other six regions, as well as localized output coefficients, which may depend on local geographical or socio-economic circumstances. In particular, the Chugoku Shikoku region had the highest FLAR among the seven regions in Japan, and it shared a significant spatial correlation with many variables in GWR. Non-successor farm households, the arable land ratio of farm households and laborers per household displayed the most significant correlation here. The explanatory ability of other variables varied greatly across regions, and specific theories and reasons behind this need to be discussed further.

3.4Summary of findings

This chapter has revealed the spatial patterns of FLA and analyzed its determinants in 2015 from geographical and socio-economic aspects by employing global (MLR) and local (GWR) regressions. Based on the former municipality boundaries, spatial patterns of FLA and its determinants were displayed and discussed. The main findings are as follows:

Firstly, FLA in Japan displays an uneven pattern and strongly corresponds to the country's geographical condition and regional agricultural development. While taking the FLAR as the measure, a nation-wide distribution of abandoned farmland is firstly displayed. The author found that most abandoned farmland is concentrated in the Chugoku/Shikoku, Kanto, Kyushu, and Chubu regions, in contrast to other regions that have good agricultural conditions, such as the Hokkaido and Tohoku regions.

Secondly, rather than geographical factors, socio-economic variables have a much higher explanatory ability. Household-related variables, such as the arable land ratio of self-sufficient farm households, displayed the most significant positive correlation with FLA, and non-successor farm households were positively correlated with FLA. In contrast, the arable land area per farm household, and the laborers per farm household were negatively correlated with FLA. For farmland-related variables, paddy field density exhibited a significant negative correlation with FLA.

Thirdly, determinants of FLA are spatially varied regarding local geographical or socio-economic circumstances. Local regression showed its superiority in terms of explanatory ability and goodness of fit for the best model. In short, FLA is a complex process driven by interactions of multiple determinants. Even within one region, the determinants might be different depending on specific local circumstances.

Finally, in regard to suggestions to prevent further abandonment. On the one hand, the Japanese government should institute some new policy or taxation reform to help farm households, especially self-sufficient farmers, to re-cultivate their land or to allow them easily transfer their land to land-holding cooperatives that have sufficient laborers (Ito et al., 2016). Japanese policy on rice production and import restrictions play a key role in keeping paddy fields in Japan. As such, policies regarding the rice market are crucial for maintaining farmland. On the other hand, farmers should seek more economical pathways to survive. For instance, in terms of non-successor farm households and aging farmers, in order to solve the lack of laborers, strengthening community-based farming, building farmland banks, (Jentzsch, 2017) and agricultural networks could be effective countermeasures to prevent future abandonment.

CHAPTER 4 INTRAREGIONAL AGRICULTURAL CHARACTERISTICS AND FLA：CASE IN THE CHUGOKU AND SHIKOKU REGION

Chapter 3 has examined the spatial patterns and determinants of FLA as well as its regional variation from the national scale. Results can provide a general understanding of FLA in Japan and understand how different geographical and socio-economic situation influence FLA. However, when focusing on intraregional circumstances, how specific agriculture and FLA are interlinked with each other is still unclear. This chapter is going to select one region and discuss the intraregional characteristics of agriculture and FLA. Results provide a profound explanation of the process of FLA and intraregional agricultural development.

Understanding how intraregional agriculture characteristics influence FLA is of great relevance to managing farmland use and FLA. Agriculture has had a long history in Japan with terraced paddy fields and rice being especially significant for Japanese people's life and culture (Fukamachi, 2017). The sector, however, has experienced stagnation since the higher economic growth period from late 1980s and is weakening year by year (Ito et al., 2016; Hisano et al., 2018). From 1990 to 2015, six regions in Japan (Hokkaido, Kanto, Chubu, Kinki, Chugoku and Shikoku, and Kyushu regions) experienced a rapid increase in FLAR. Among these regions, the FLAR in Chugoku and Shikoku region exhibited the highest level of FLA. However, few previous scholarships have put emphasize on FLA in this region. Empirical studies have found that FLA and agricultural structures are strongly correlated worldwide (Gellrich et al., 2007; Lasanta et al., 2015; Uematsu et al., 2010). However, few studies have shed light on differences in intraregional agriculture characteristics and their relationship with FLA. This relationship is crucial for understanding explicit spatial and intraregional variations of agriculture characteristics or structures and causes of FLA. In Japan, an increasing number of studies have emphasized FLA by local case studies. However, only a few studies have investigated how and to what extent FLA occurs with due consideration of intraregional agriculture characteristics at the regional context, especially in west Japan.

Therefore, this chapter aims to fill this gap and to discuss FLA in connection with particular intraregional agriculture circumstances. Data from the 2015 census of agriculture are utilized to outline the intraregional agricultural characteristics and FLA with the Chugoku and Shikoku region. Qualitative and quantitative aspects of agricultural characteristics and FLA have been evaluated. There are three main objectives:

(1) to show and understand the spatial variation and uneven pattern of agriculture characteristics or structures in the Chugoku and Shikoku region;

(2) to explain the factors or causes of FLA by taking agriculture characteristics as dependent variables instead of individual factors;

(3) to discuss the relationship between agriculture characteristics and FLA.

Results can support both central and local governments to make better-informed farmland use decisions and mitigate further FLA through more comprehensive farmland use suggestions, eventually preserving regional agriculture.

4.1Background and Issues of Intraregional FLA

In the previous chapter, the spatial pattern and determinants of FLA on a national scale were examined. Such results provided us with a clear understanding of the general characteristic of FLA in Japan. However, within regions that there exist spatial variations of FLA which might be caused by the uneven development of agriculture. Hence, we should pay careful attention to discrepancies in the mechanisms of FLA, which might adequately reflect the intraregional characteristics of agriculture.

4.1.1 Agriculture in the Chugoku and Shikoku region

Similar to the national trend, agriculture is declining in the Chugoku and Shikoku region, with a continuous decrease of farmers and farming households. Based on the national census of agriculture and forestry in 2015, the total number of farmers in the Chugoku subregion decreased by 15.1%, and the Shikoku subregion decreased by 14.1% compared with 5 years ago. Commercial farmers decreased by 19.4% in the Chugoku subregion and 17.9% in the Shikoku subregion compared to five years ago. Regarding the demographic situation, the agricultural work population decreased by 20.0% in the Chugoku subregion and 19.7% in the Shikoku subregion compared to five years ago. The average age of the agricultural work population is 3.7 years older in the Chugoku subregion and 0.8 years older in Shikoku subregion than the national average (66.4 years). The proportion of people aged 65 and over is 76.1% in the Chugoku subregion, which is 12.6% higher than the whole country.

Compared with the national level, agriculture in the region is maintained at a small scale. The arable land area in the Chugoku and Shikoku region is 0.64 ha, less than the national average of 1.27 ha (Table 2-2, 2-3). In the Chugoku subregion, aging of farmers and depopulation are wide-spread, leading to an increase of FLA, which accelerated the forestation and wild animal damages in farmland (Bureau of the Chugoku and Shikoku Agricultural Administration, 2016). HMAs occupy a large part of the subregion, and agriculture is mostly centered on rice production, especially in the Chugoku Mountains. Okayama, Shimane, and Tottori Prefectures have large alluvial plains created by rivers, and those well-conditioned farmlands are specialized in rice production.

In the Shikoku subregion, unique agriculture products and flowers suitable for warm climates are produced in greenhouses. For example, in mountain regions of southern Shikoku, farmers benefited economically from the warm climate and produced many early crops and vegetables for other areas of Japan (Kanzaka, 2009). Although there are large areas with mountains in the Shikoku subregion, in an attempt to utilize the unfavorable geographical condition, remaining farmers developed agriculture based on local agriculture conditions. Multiple crops such as rice, wheat, and soybeans have been widely cultivated as well as fruit and livestock production on sloping farmland and hills.

In the central areas of the Chugoku and Shikoku region, known as Setouchi, many cities and various industries emerged along the Seto Inland Seaside, which makes the Setouchi region a famous industrial area in Japan. With the afore-mentioned geographical and socio-economic characteristics in the Chugoku and Shikoku region, agriculture exhibits unique features. The FLAR in the region is continuing to be the highest in Japan until 2015 (MAFF, 2015). As such, the effects of agricultural characteristics on FLA in this region merit more in-depth discussion.

4.1.2 FLA in the Chugoku and Shikoku region

Until 2015, the Chugoku and Shikoku region exhibited the highest level of FLA among seven regions of Japan and the highest level was recorded in Hiroshima Prefecture (Figure 4-1). Abandoned farmland area increased by 4.8% in the Chugoku subregion and 3.9% in the Shikoku subregion compared to five years ago (increased by 6.8% nationwide). The abandoned area of farmland for non-farm households increased by 10.1% in the Chugoku subregion and 8.8% in the Shikoku subregion compared to five years ago (12.8% increase nationwide) (MAFF, 2015).

The total abandoned farmland area of all farmers and land-holding non-farm farmers increased by 4.8% in the Chugoku subregion and 3.9% in the Shikoku subregion compared to five years ago. There are distinctive characteristics of FLA pattern in the Chugoku and Shikoku region. The areas with the highest FLAR were the small islands and the coastal areas of the Seto Inland Sea, especially on the Chugoku subregion side. In the Chugoku subregion, Hiroshima and Okayama Prefectures also exhibit a high FLAR in the mountainous farming areas along their border. In the Japan Seaside, coastal areas of Shimane Prefecture also experienced a high FLAR. In the Shikoku subregion, high FLAR are chiefly concentrated in the mountainous farming areas of Kochi and Tokushima Prefectures.

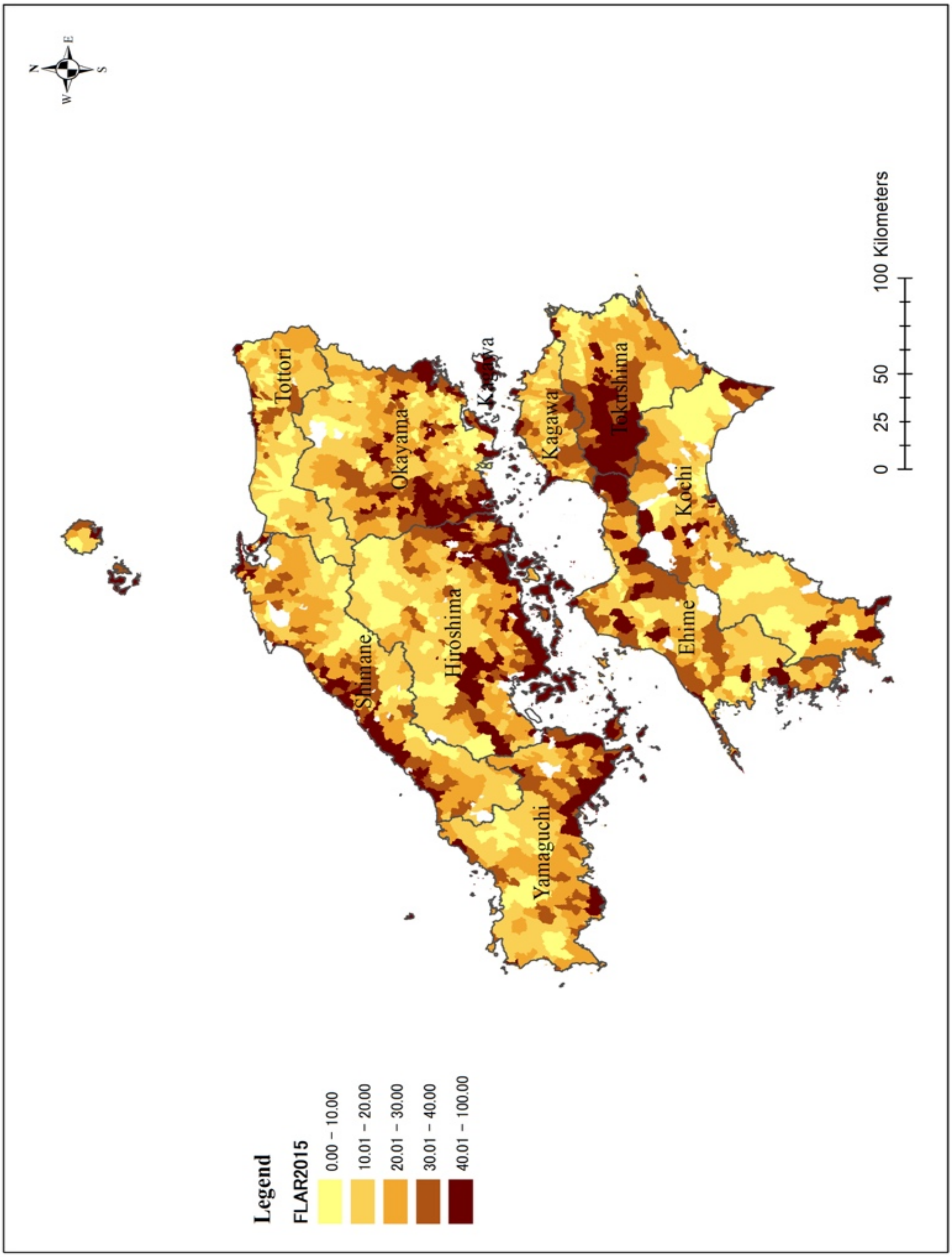


Figure 4-1 Spatial distribution of FLAR in Chugoku Shikoku region (2015)

Source: *Ministry of Agriculture, Forestry and Fishery (MAFF)*

4.2 Intraregional Agricultural Characteristics in the Chugoku and Shikoku Region

4.2.1 Definition of agricultural characteristics

Agricultural characteristic is a broad concept, which can describe and measure different dimensions of agriculture. Specifically, MAFF conducts an agricultural census every five years to track the changes in these characteristics, such as agriculture scale, management statutes, farmland share, household types, labor conditions, agriculture products. Through such characteristics, the author can easily divide the whole region into different subregions on the basis of the type and organization of agriculture that occur there. Studies have analyzed the characteristics of mountainous villages (Okahashi, 1986; Okahashi, 1997) and agricultural regions (Nihei, 2006). Results indicated the classification of regions under different rural or agricultural characteristics. Such analysis also helps understand regional development and inform region-specific administrative decisions.

4.2.2 Identifying intraregional agricultural characteristics

To identify the intraregional agricultural characteristics in the study region, PCA was employed to conduct dimension reduction and identify the number of different agricultural characteristics. As discussed above, the PCA method was ideal for reducing the dimensionality of the initial data set, which involved a large number of interrelated variables. As a result, eight PCs with eigenvalues of 5.569, 4.345, 2.543, 1.818, 1.633, 1.342, 1.072, and 1.006 were identified for the description of intraregional agricultural characteristics. The author conducted a Kaiser-Meyer-Olkin (KMO) test and a Bartlett's test of sphericity (Patil & Kokate, 2017). Results show that the KMO statistics are higher than 0.60 (0.716) and Bartlett's test of sphericity provides values of 0.000, both of which indicate the suitability of the dataset for running PCA. For accumulated dispersion, those eight PCs can explain about 77.3% of the variance for the 25 variables being selected; the heaviest loadings have been marked as bold-faced in Table 4-1.

Table 4-1. List of rotated principal component matrix for all agricultural characteristics

Variables	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8
A24 Rate of farm households with more than 10 million yen in sales	**0.869**	0.145	0.029	0.037	0.123	-0.024	0.118	0.056
A14 Solely vegetable production farm household rate	**0.841**	-0.127	-0.114	-0.102	0.072	0.118	-0.026	0.039
A9 Farmers average ages	**-0.828**	-0.168	-0.069	-0.021	0.136	0.127	0.036	0.054
A10 Average number of laborers per farm household	**0.826**	-0.012	0.280	-0.111	-0.063	-0.027	-0.182	-0.061
A8 Ratio of second type part-time farm households	**-0.686**	-0.022	-0.305	0.051	-0.002	-0.560	0.017	-0.005
A7 Ratio of first type part-time farm households	**0.601**	0.269	0.240	0.264	0.061	0.016	0.011	0.276
A2 Arable land ratio of self-sufficient farm households	-0.062	**-0.929**	0.060	0.051	0.037	0.028	-0.072	-0.040
A5 Ratio of business farm household	0.025	**0.905**	-0.055	-0.228	-0.030	-0.049	0.137	0.001
A25 Share of agriculture management bodies with less than 0.5 ha farmland	-0.052	**-0.876**	0.117	-0.108	-0.026	0.003	0.107	-0.031
A4 Arable land area per household	0.099	**0.867**	**-0.084**	0.148	0.127	-0.005	-0.008	0.058
A15 Rate of farm households producing only vegetables	0.052	-0.084	**0.938**	-0.067	-0.139	0.067	0.043	0.006
A22 Fruit land rate	0.052	-0.086	**0.934**	-0.136	-0.095	0.134	-0.020	-0.058
A20 Paddy field rate	-0.213	0.156	**-0.806**	0.168	-0.354	-0.052	0.179	0.105
A13 Solely rice production farm household rate	-0.563	0.106	**-0.655**	0.144	-0.120	-0.107	0.282	-0.029
A3 Arable land ratio of land tenure non-farm households	-0.018	-0.054	-0.220	**0.779**	-0.215	-0.096	-0.011	-0.017
A18 Ratio of leased-in land	-0.034	0.229	-0.054	**0.748**	0.212	0.004	0.017	0.003
A6 Share of land tenure non-farm household	0.048	-0.276	-0.085	**0.733**	-0.228	0.223	-0.081	-0.010
A21 Cropland rate	0.280	-0.150	0.146	-0.109	**0.712**	-0.075	-0.267	-0.100
A16 Solely husbandry production farm household rate	-0.038	0.135	-0.093	-0.006	**0.632**	-0.009	-0.034	-0.002
A1 Forest rate	-0.309	-0.017	0.073	-0.113	**0.506**	0.261	0.452	0.125
A12 Ratio of non-successor farm households	0.056	0.002	0.150	0.096	0.039	**0.884**	0.108	0.050
A11 Ratio of workers below 65 years	0.400	0.328	-0.056	0.138	0.231	**-0.495**	0.308	0.207
A17 Combined management farm household rate	0.002	-0.033	0.138	0.028	0.196	-0.023	**-0.797**	0.149
A19 Ratio of leased-out land	0.140	0.045	-0.050	-0.077	-0.099	0.051	-0.162	**0.863**
A23 Rice commissioned work management body rate	-0.276	0.143	-0.167	0.392	0.222	-0.134	0.197	**0.455**
Eigenvalues	5.569	4.345	2.543	1.818	1.633	1.342	1.072	1.006
% of Variance	22.276	17.38	10.174	7.27	6.532	5.367	4.289	4.026
Cumulative %	22.276	39.656	49.829	57.1	63.631	68.998	73.287	77.313

* The heaviest loadings have been marked as bold faced.

From Table 3-1, it can be clearly seen that the PC 1 explained 22.3% of the total variance in the dataset. This component is characterized by strong positive associations with the rate of farm households with more than 10 million yen in sales, the rate of farm households producing only vegetables, the average number of laborers per farm household, and the rate of first type part-time farm households. PC1 is also negatively affected by the farmers' average ages and the ratio of second type part-time farm households. Therefore, this PC 1 seems to capture *the activeness of agriculture*.

PC 2 accounted for 17.4% of the total variation in the data set, and it is positively associated with ratio of business farm households among all farms and arable land area per household. PC 2 was negatively associated with the percentage of arable land occupied by self-sufficient farm households and the share of agriculture management bodies with less than 0.5 ha of farmland. In combination, these characteristics capture *the sales orientation and scale of agriculture*.

PC 3 explained 10.2% of the variance and is positively associated the percentage of households engaged solely in fruit production and the percentage of arable land engaged in fruit production; it is negatively associated with the percentage of arable land consisting of paddy fields and the percentage of farms engaged solely in rice production. In combination, this component seems to capture *the fruit production agriculture*.

PC 4 explained 7.3% of the variance and is positively associated with the percentage of arable land held by non-farm households, the percentage of arable land that is leased-in, and the percentage of all households that hold land but are non-farming households. Therefore, this component seems to capture *the impact of non-farm households on agriculture*.

PC 5 explained 1.6% of the variance and is associated with the percentage of arable land devoted to vegetable or dry season crop production, the percentage of farm households devoted solely to livestock production, and the percentage of total land area covered by forests. Therefore, this component seems to capture *the dependence on rice production*.

PC 6 explained 1.3% of the variance and is positively associated with the percentage of farm households with no designated successor and the percentage of workers who are under 65 years of age. Therefore, this component seems to capture *the status of agricultural succession*.

PC 7 explained 1.1% of the variance and is negatively associated with the percentage of farms operated under combined management. Therefore, this component seems to capture *the diversification of agriculture*.

PC 8 explained 1.0% of the variance and is positively associated with the percentage of arable land that is leased-out land, and the rice commissioned work management body rate. Here, commissioned work refers to the outsourcing of agricultural work or leasing of farmland by elder farmers due to lack of laborers. Therefore, this component seems to present *the transition of farmland*.

4.2.3 Spatial variations of intraregional agriculture

All of the PCs indicate that there are obvious intraregional differences in the agricultural characteristics across the Chugoku and Shikoku region. Variation in the PC (1-8) scores on the regional map is shown in Figures 4-2 to 4-9; the positive values correspond to red triangles, while the negative values are blue dots. Figure 4-2 shows that PC 1, *the activeness of agriculture*, dominates in the southern Shikoku subregion (Kochi and Tokushima Prefectures), the Seto Inland Sea area, and the northern part of Chugoku subregion (Tottori Prefecture). Figure 4-3 indicates that PC 2*, the sales orientation and scale of agriculture*, is the highest in west Yamaguchi, central Hiroshima, Tottori, and to the west of Ehime and Kagawa Prefectures. Figure 4-4 demonstrates that PC 3, *the fruit production agriculture*, is the highest in coastal areas and Tottori, Ehime, Kagawa, and Tokushima Prefectures. All of these areas are famous for fruit production, with Tottori Prefecture being famous for Japanese pear production. Tokushima and Kagawa Prefectures are famous for yuzu production, and Ehime Prefecture and the Seto Inland sea areas are the biggest producers for citrus fruits. Figure 4-5 shows that PC 4, *the impact of non-farm households on agriculture*, is the highest in the southern part of Okayama, Hiroshima, Tottori and the southern part of Ehime. Figure 4-6 suggests that PC 5, *the dependence on rice production*, is the highest in the northern part of Okayama, Hiroshima, Shimane, and the southern part of Ehime. Figure 4-7 shows that PC 6, *the status of agricultural succession*, is the most serious in Hiroshima, Yamaguchi, Ehime, and Kagawa Prefectures. Figure 4-8 indicates that PC 7, *the diversification of agriculture*, is the highest in the southern part of Okayama, Hiroshima, Shimane, Yamaguchi, and Kagawa Prefectures. Finally, Figure 4-9 shows that PC 8, *the transition of farmland*, is the highest in the Shimane and Yamaguchi Prefectures.

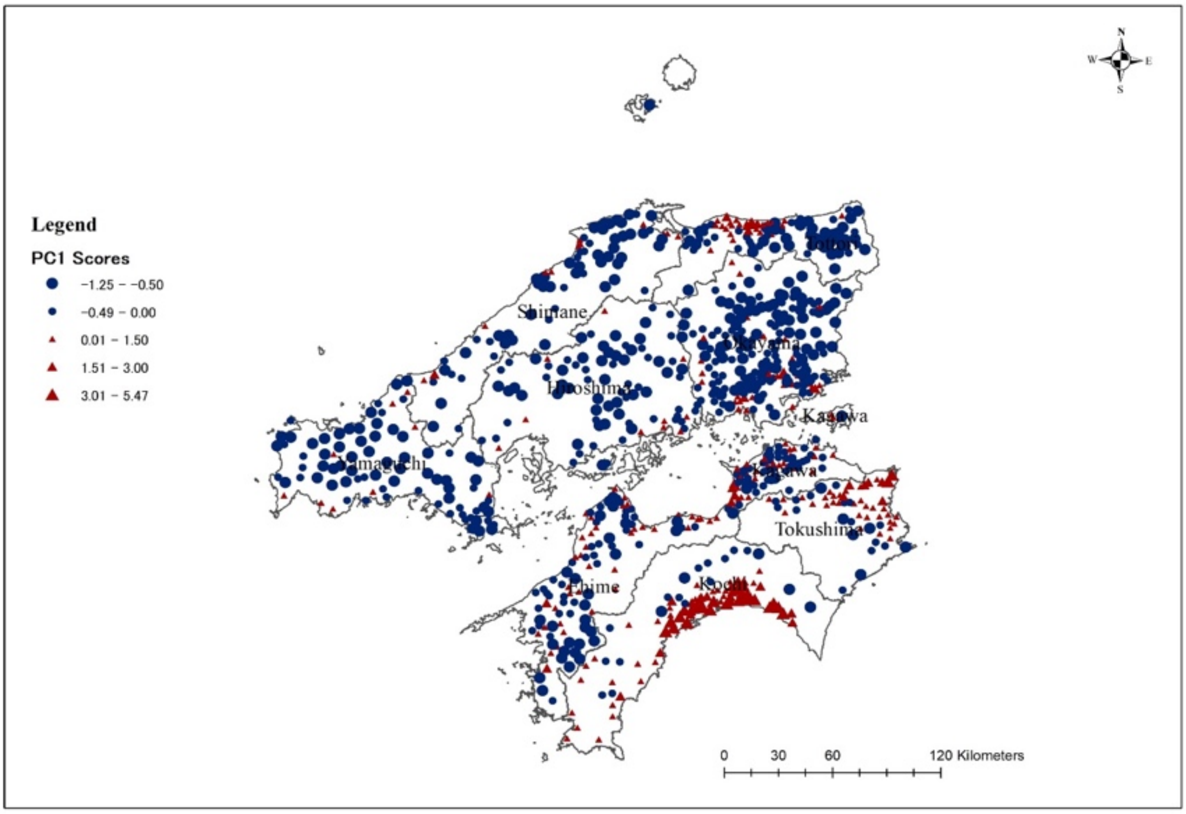


Figure 4-2 Distribution of PC 1 scores in the Chugoku and Shikoku Region

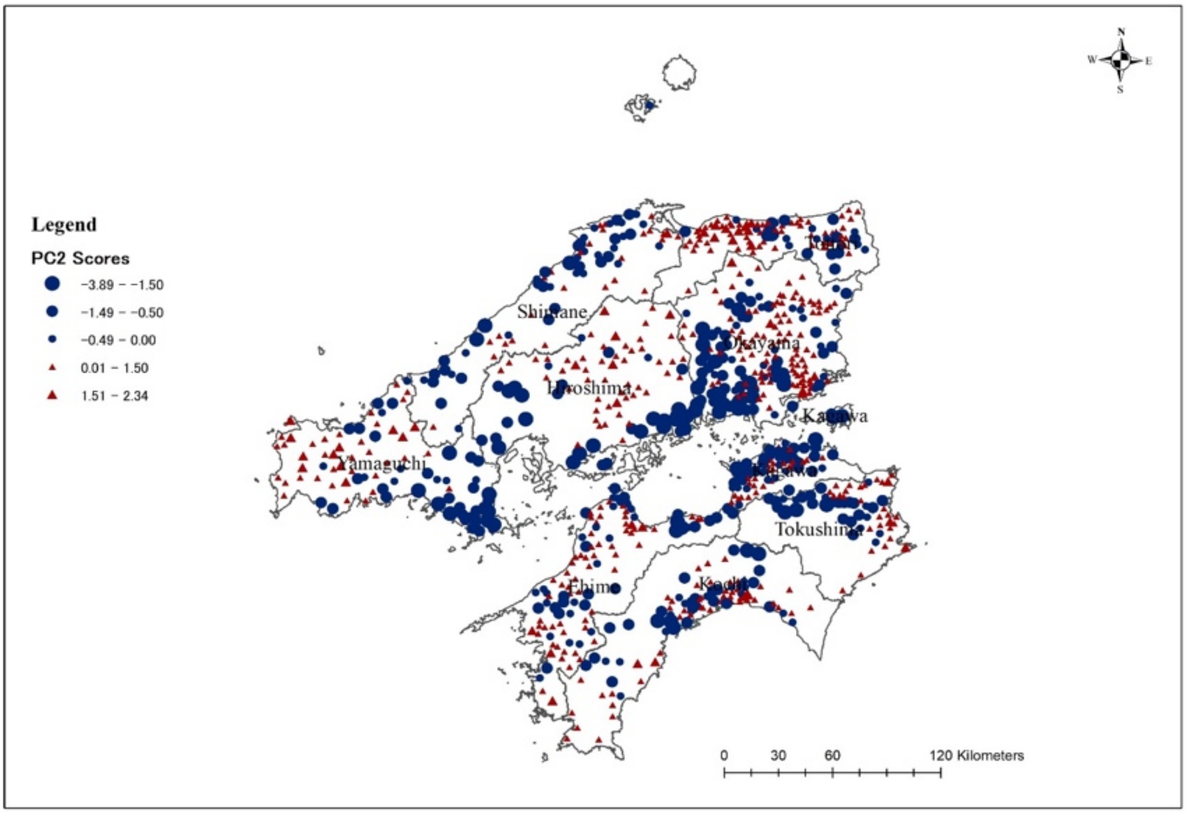


Figure 4-3 Distribution of PC 2 scores in the Chugoku and Shikoku Region

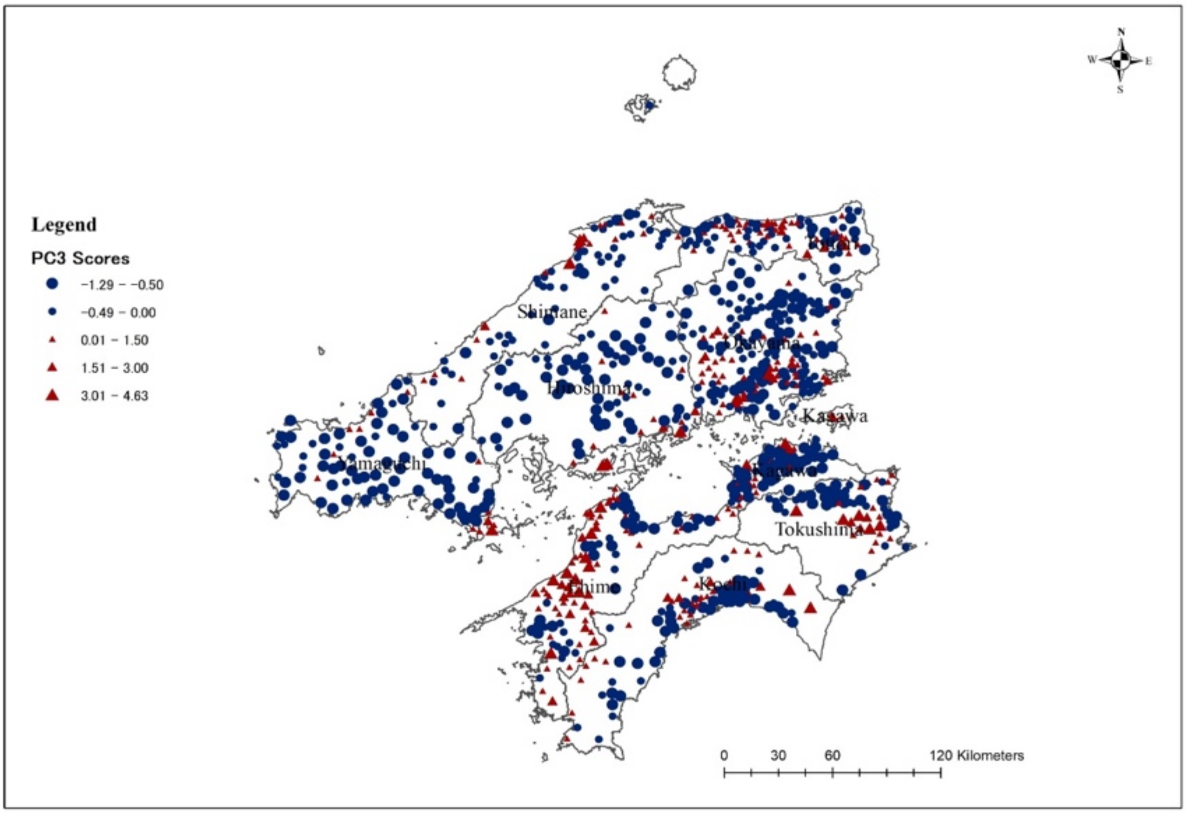


Figure 4-4 Distribution of PC 3 scores in the Chugoku and Shikoku Region

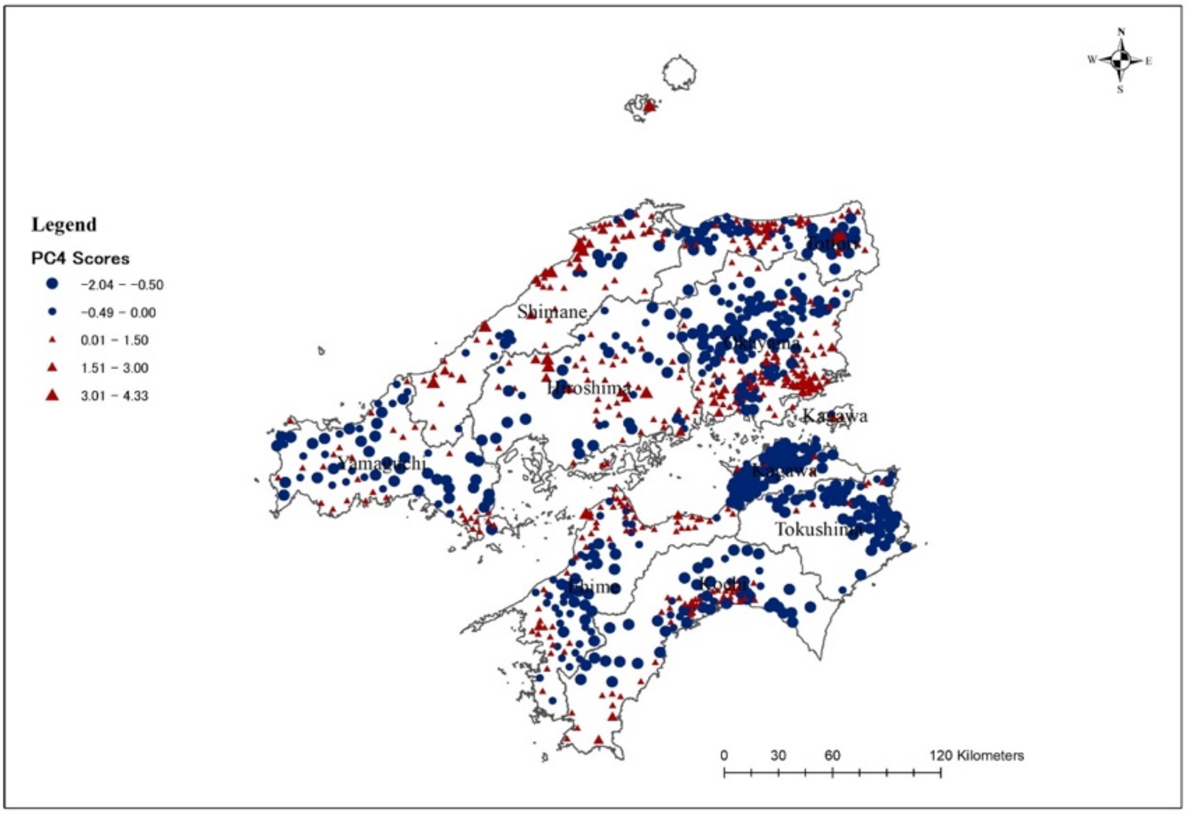


Figure 4-5 Distribution of PC 4 scores in the Chugoku and Shikoku Region

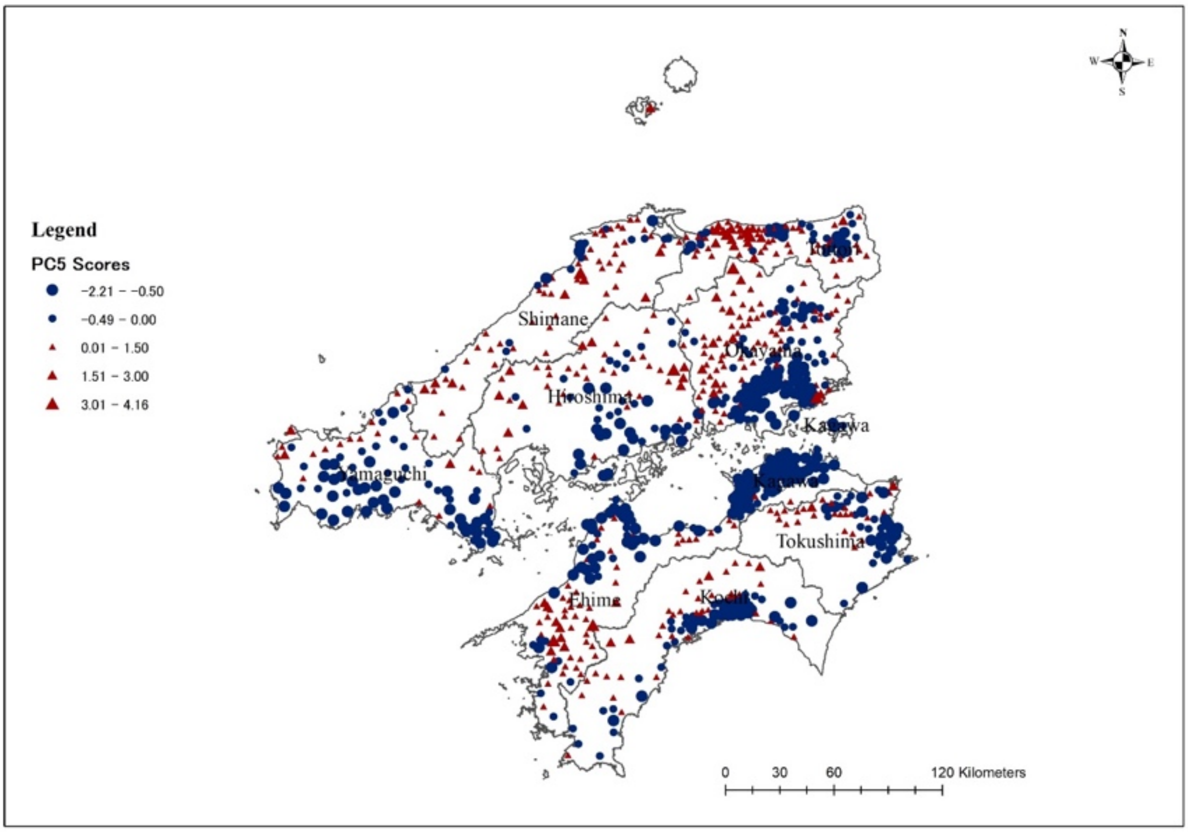


Figure 4-6 Distribution of PC 5 scores in the Chugoku and Shikoku Region

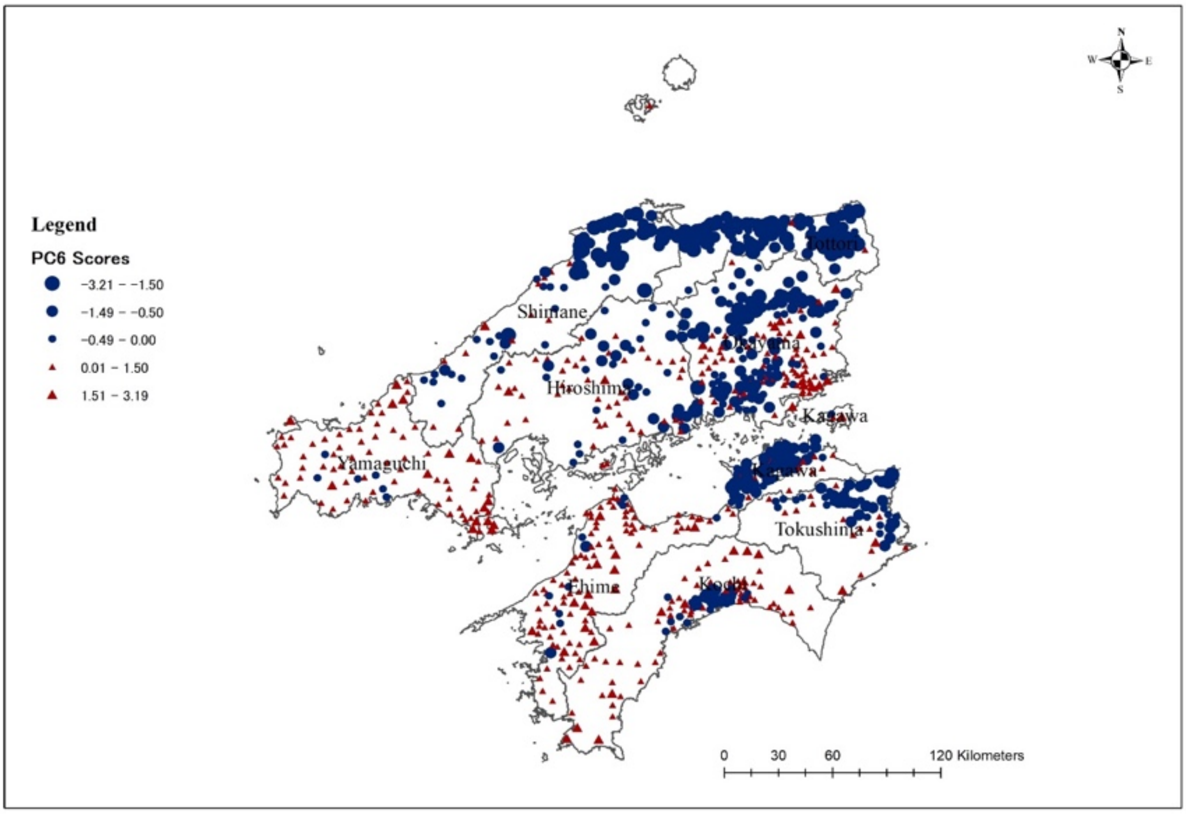


Figure 4-7 Distribution of PC 6 scores in the Chugoku and Shikoku Region

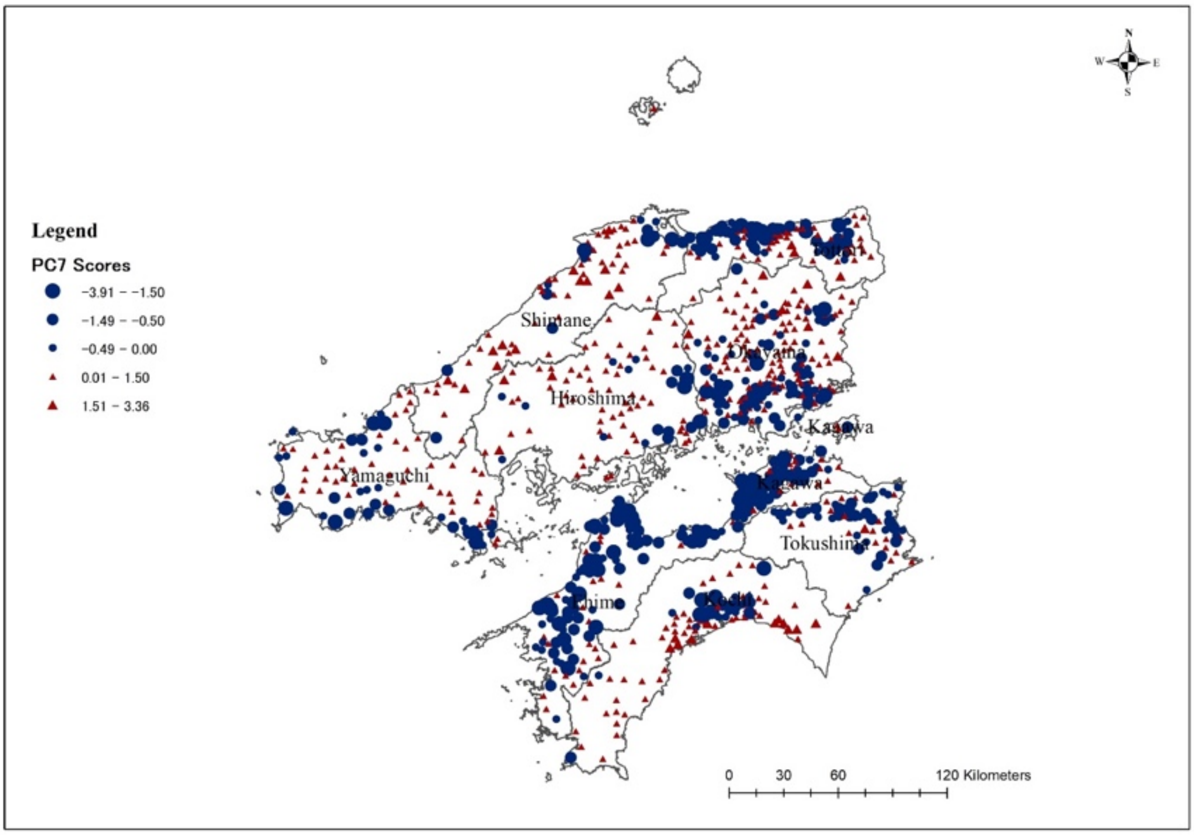


Figure 4-8 Distribution of PC 7 scores in the Chugoku and Shikoku Region

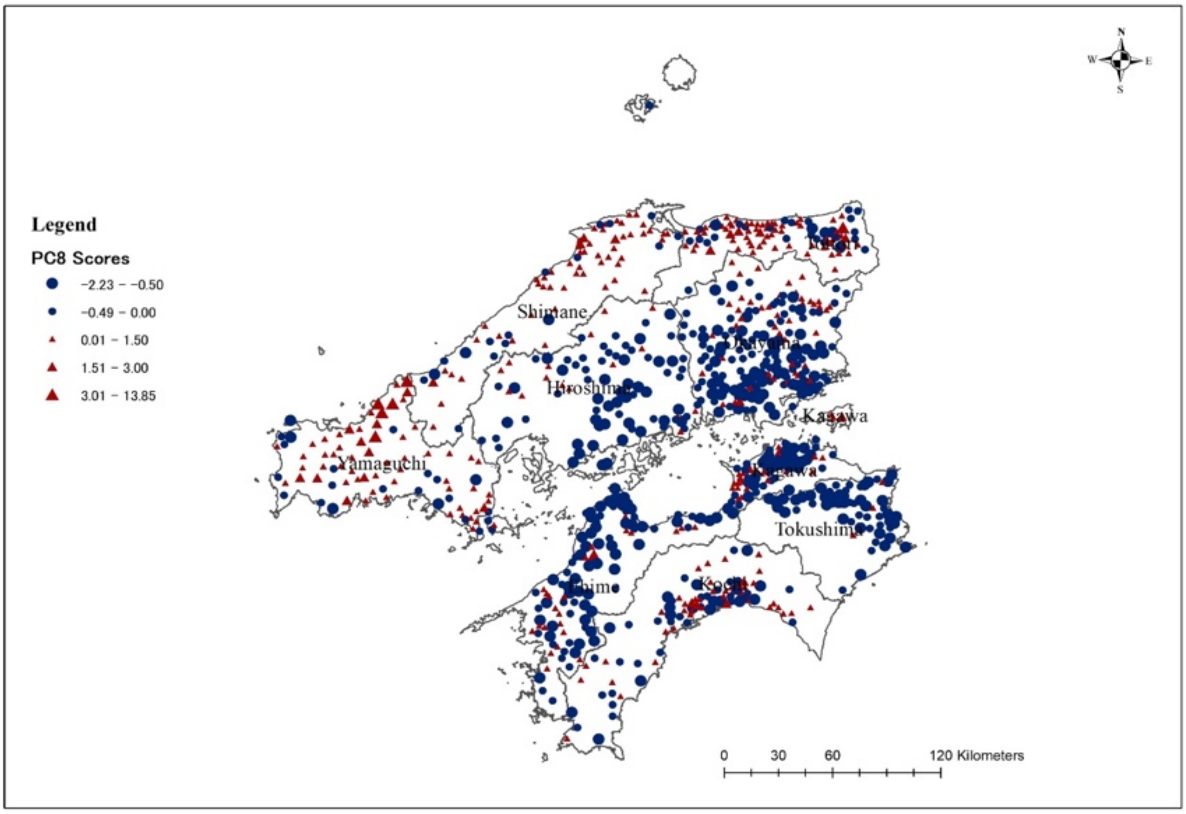


Figure 4-9 Distribution of PC 8 scores in the Chugoku and Shikoku Region

4.3Intraregional Agricultural Characteristics and FLA

4.3.1 How agricultural characteristics affect FLA

In Japan, agricultural regions are classified by MAFF as either urban areas, flatland farming areas, intermediate farming areas, or mountainous farming areas according to their geographical conditions (Figure 4-10) (MAFF, 2015). Table 4-2. depicts the standard indicators and characteristics of those four farming areas and their definitions. Urban areas refer to areas where the population density is 500 people /km^2 or more and the (Densely Inhabited District) DID area occupies 5% or more of the habitable area. Flatland farming area pertains to areas that either have 20% arable rate and less than 50% forest or have 50% or more arable rate. Intermediate farming area stands for areas between flat and mountainous farming areas with forest rates between 50% and 80% and arable land with many slopes. Mountainous farming area means areas with a forest rate of more than 80% and an arable land rate of less than 10%.

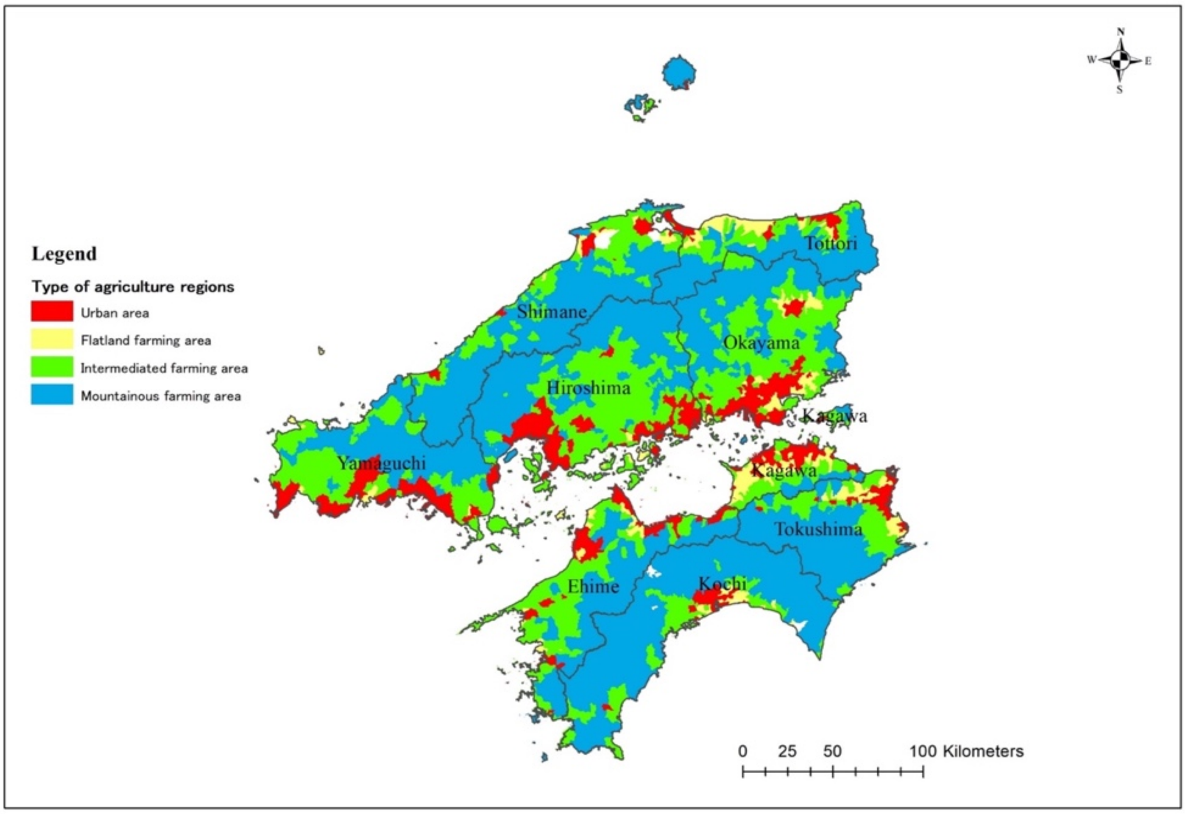


Figure 4-10 Spatial distribution of agricultural area types in the Chugoku and Shikoku region

Source*: Ministry of Agriculture, Forestry and Fishery (MAFF), http://www.maff.go.jp/e/index.html*

Table 4-2. Types of farming areas in the Chugoku and Shikoku region

Agricultural area type	Explanation
Urban area	Areas where the population density is 500 people /km^2 or more and the (Densely Inhabited District) DID area occupies 5% or more of the habitable area.
Flatland farming area	Areas that either have 20% arable rate and less than 50% forest OR have 50% or more arable rate.
Intermediate farming area	Areas between flat and mountainous farming areas with forest rates between 50% and 80% and arable land with many slopes.
Mountainous farming area	Areas with a forest rate of more than 80% and an arable land rate of less than 10%.

Source: *MAFF.*

In this study, the author explored correlations between agricultural characteristics and FLA and how they vary in different farming areas. The author divided study region into the four farming area types discussed in Table 4-2 in order to minimize the influence of different geographical conditions in MLR. Factor scores for PCs 1-8 were retained as independent variables, and a stepwise MLR was performed for four different agriculture areas. The obtained results demonstrate that the 8 PCs have different explanatory power for FLA in the Chugoku and Shikoku region (Table 4-3). All of the coefficients in the regressions are statistically significant as their p-values are each smaller than 0.05.

The MLR results indicate that, PC 2 has the strongest negative correlation for each of the four agriculture regions. As PC 2 stands for the sales orientation and scale of agriculture, it can be concluded that as the size of farm operations increases, FLA declines in this study region. As previously discussed, the data in the study consist of not only individual farm households but also agriculture management bodies. Therefore, the agriculture scale and sales status of both will affect FLA. PC 6 was another significant factor, which represents the status of agricultural succession, exhibits the strongest positive correlation for each of the four types of agriculture regions. In other words, the lack of agriculture successors in the study region increases FLA. MLR has the highest explanatory ability for FLA in flatland farming areas (adjusted R_{adj}^2 = 62.2%), followed by intermediate farming areas (adjusted R_{adj}^2 = 61.3%), urban farming areas (R_{adj}^2 = 45.6%), and mountainous farming areas (R_{adj}^2 = 40.9%).

Table 4-3. MLR models for FLA prediction using PCs

Agriculture Regions	Urban area	Flatland farming area	Intermediate farming area	Mountainous farming area	Total
PC 1		-0.119**	-0.086**		-0.05**
PC 2	-0.565**	-0.734**	-0.721**	-0.605**	-0.638**
PC 3	0.255**	0.431**	0.278**		0.247**
PC 4				0.129**	0.077**
PC 5		0.202**	0.114**		0.094**
PC 6	0.324**	0.240**	0.230**	0.123**	0.194**
PC 7		-0.117**		-0.141**	-0.071**
PC 8			-0.099**		-0.068**
N	140	151	389	190	860
R_{adj}^2	0.456	0.622	0.613	0.409	0.528

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.3.2 How to manage further FLA

This study finds that PC 2 (*the sales orientation and scale of agriculture*) has the strongest negative influence on FLA. Previous work finds that agricultural scale, in terms of farmland size, reduces FLA mainly because it takes more labor and economic costs to maintain small-size and dispersed farmlands (Grədinaru et al., 2015; Kolecka et al., 2017). In this study, scale and sales orientation also affect labor costs and farm income. Indeed, high cultivation costs and low yields are more likely to cause FLA (Gellrich & Zimmermann, 2007). As such, second type part-time farm households whose non-farm income exceeds their farm income are believed to focus less on agriculture, ultimately leading to abandonment. As shown in Figure 4-3, high values of PC 2 are clustered in the central Chugoku subregions and southern Shikoku subregion. As a result, FLA was relatively low in these areas. In contrast, the increase in abandoned farmland in the study region especially along the coastal areas of the Seto Inland Sea can be ascribed to the small scale and abandonment of citrus fruit fields due to the low profit. As Figure 4-4 shows, high levels of PC 3 (*the fruit production agriculture*) are concentrated in the coastal areas of the Seto Inland Sea, which are dominated by urban areas, flat farming areas, and intermediate farming areas. Table 4-3 also displays significant effects of PC 3 on FLA in these three farming areas. Although the farmland's geographical condition in these areas is better than in mountainous farming areas, abandonment occurred, nonetheless. Figure 4-11 displays the change of abandoned farmland and orange (in Japanese: *Mikan*) production areas in the study region from 1975 to 2015. It can be observed that orange production areas started to decline beginning in 1975, and abandoned farmland areas increased each year, particularly after 1985. In postwar Japan, the commercialization of agriculture progressed nationwide and even in the Chugoku and Shikoku region. In most coastal areas, including islands in the Seto Inland Sea, oranges became one of the most profitable products. However, after 1970, the overproduction of oranges led to lower prices. As a result, only a few traditional production areas remained in parts of Ehime and Hiroshima Prefectures (Kanzaka, 2009). In contrast, most of the more recently established production areas gave up fruit production due to the market conditions and an insufficient labor force. This trend resulted in the abandonment of fruit fields in the coastal areas and contributed chiefly to the increase in FLA.

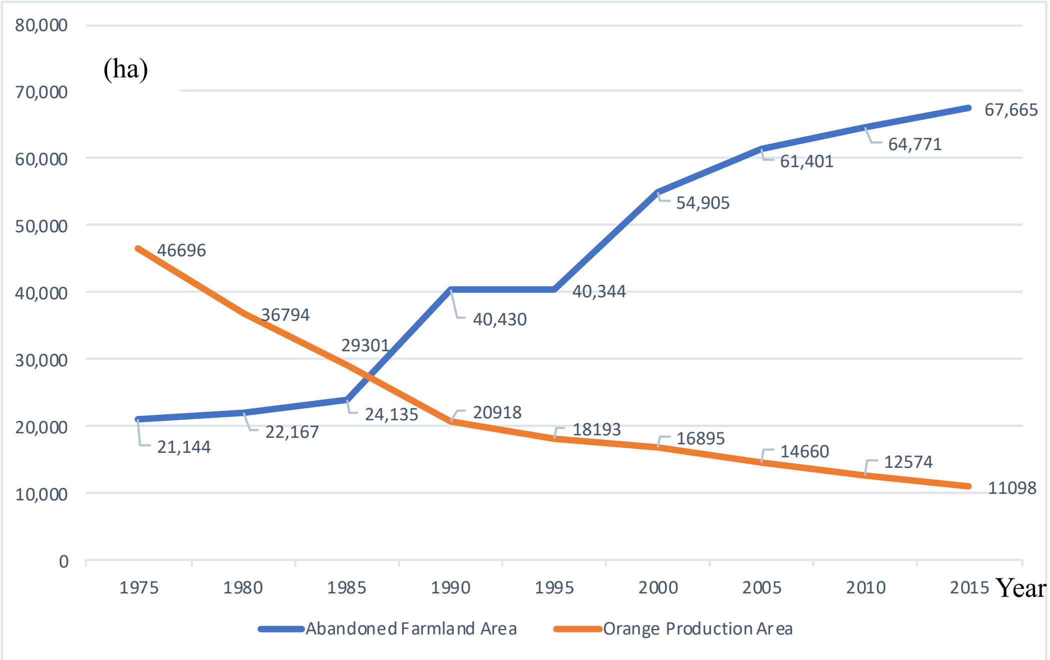


Figure 4-11 Change of abandoned farmland and orange production areas in the study region.

Source: *MAFF, http://www.maff.go.jp/e/index.html.*

High FLAR in the southern Chugoku subregion, particularly in Hiroshima and Okayama Prefectures, are largely due to the serious aging and depopulation. As Table 4-3 indicates, PC 6 (*the status of agricultural succession*) seems to influence FLA over the study region. The aging of farmers (Ruskule et al., 2013; Pazúr et al., 2014; Terres et al., 2015) and the lack of successors (Keenleyside et al., 2010; Yamashita & Hoshino, 2018) for farms have been found to affect FLA by many previous studies. In Japan, rural depopulation is said to have begun in the Chugoku subregion, and with many settlements facing the issue of lack of laborers and successors (Kanzaka, 2009). In addition, there was a rapid growth of the industrial labor market on the Seto Inland Sea coast, with a corresponding and intensive outflow of the population in this direction from the mountain villages. For this reason, the agriculture that remained was small scale and mainly for subsistence farming. This is contrary to the situation in northern Japan, especially in the Tohoku region, where depopulation was not so serious, and the local labor shortage did not spread to neighboring areas. Instead of entire families, only individuals there left their homes to take employment in metropolitan areas (Okahashi, 1996). Therefore, the region enjoys better labor conditions in the agriculture sector than in southern Japan. In the future, improving labor accessibility and strengthening family kinship ties in the Chugoku and Shikoku region will be essential for solving the labor shortage.

4.4Summary of findings

Chapter four is the summary of intraregional agricultural characteristics and FLA in the Chugoku and Shikoku region. As assumed, FLA is generally a complex process, which cannot be fully described by a single variable or determinant. This study analyzed agricultural characteristics and FLA in the Chugoku and Shikoku region in Japan, which had the highest FLAR until 2015. The author applied a combination of PCA and MLR methods to explain the driving forces or processes of FLA by different domains of agricultural characteristics extracted from variables. The main conclusions are as follows.

First, there are significant intraregional differences in the agricultural characteristics across the Chugoku and Shikoku region with eight significant PCs being extracted. They are grouped as PC 1 (*the activeness of agriculture*), PC 2 (*the sales orientation and scale of agriculture*), PC 3 (*the fruit production agriculture*), PC 4 (*the impact of non-farm households on agriculture*), PC 5 (*the dependence on rice production*), PC 6 (*the status of agricultural succession*), PC 7 (*the diversification of agriculture*), and PC 8 (*the transition of farmland*).

Second, the author found that variables measuring agricultural characteristics explain nearly 52.8% of the variation in FLA in the study regions. The PC 2, presenting the sales orientation and scale of agriculture, has the strongest negative correlation to FLA in the region, while PC 6, presenting the status of agricultural succession displayed the strongest positive correlation to FLA. The highest abandonment in Seto Inland Sea areas is chiefly due to the low profit of fruit production and the changes of the market prices.

Third, in flatland farming areas and intermediate farming areas, where agriculture is more stable and easier to maintain, FLA is more strongly influenced by changes in agricultural characteristics than by geographic conditions, such as slope or altitude.

CHAPTER 5 FLA AT THE LOCAL SCALE AND COMMUNITY-BASED FARMING: CASE IN HIROSHIMA PREFECTURE

The previous two chapters have discussed the processes of FLA from the national and intraregional scales in Japan; the spatial patterns, regional or intraregional variations and determinants of FLA have been examined and presented. Specifically, chapter 3 emphasized the national scale FLA and explored the determinants of FLA and regional variations using agricultural census data. Chapter 4 focused on one specific region (the Chugoku and Shikoku region) and searched for intraregional agricultural characteristics and FLA. Both chapters allowed us to understand the issue of FLA from a macro scale to form a clear understanding of FLA in Japan. However, from the local scale, the situation of FLA especially the opinions of individual farm households and Community-Based Farm Cooperatives (here after: CBFCs)[8] (in Japanese: *Syuraku Einou*) who are the major laborers engaged in agriculture are still largely unknown. Local farmers and farm households put a lot of effort into promoting agriculture development, which also contributes to the prevention of further FLA. Therefore, this chapter mainly discusses the roles of individual farm households and CBFCs in maintaining agriculture and mitigating future FLA. This chapter also includes some results from the Taoyaka Program onsite team project in Sera Town, which was conducted in 2018 to understand the agriculture development in HAMs.

In recent years, in the face of labor shortage and population outflow in rural areas, community-based agriculture (CBA) or community-supported agriculture (CSA) (Opitz et al., 2019) have been widely introduced and encouraged especially in rural areas worldwide (Peredo & Christman, 2006; MacIas, 2008; Thornton, 2009; Z. Liu et al., 2016; Gorman, 2018). As a rural development approaches both CBA and CSA were introduced to reverse rural recession and cope with rural settlement dispersion after the Second World War (W. Liu et al., 2018). The form of CBA or CSA implies the capacity to extend beyond economic exchange to include social roles, motivations, and benefits for both farmers and consumers (Balázs et al., 2016) by sharing the 'risks and rewards' of farming more equitably (Gorman, 2018).

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[8] Different from Japanese Agriculture (JA), called Nōkyō until 1992, is a producer cooperative organization based on the Nōkyō Law of 1947.

In Japan, CBFC is a kind of agriculture management body that consists of one or more agriculture settlements aimed at improving agricultural productivity and secure farm labor (Ichikawa, 2011). The initial concept of community-based enterprise (CBE) was defined as a community acting corporately as both entrepreneurs and enterprises in pursuit of the economic benefit (MacIas, 2008). CBFCs usually incorporate entities allowing farmers to use farmland under certain conditions, which were originally based on an amendment of the Agricultural Land Law of 1962 (Jentzsch, 2017). CBFC members then divided different roles by utilizing the abundant talents of the community settlements, and by establishing a stable management system, accepting new farmers when elder farmers retired, thereby making it possible to build a permanent and sustainable development[9]. When setting up a CBFC, farmland is accumulated by lease contract (setting of usage right). When farmland accumulates, farmers will cultivate crops according to land use plans while also considering productivity. Working with large machines is performed by the core workers, while daily management such as levees management is undertaken by regular workers and employees. Because of aging and depopulation in rural Japan, CBFC has become a new solution for agriculture revitalization caused by labor shortages in farm households.

Figure 5-1 clearly illustrates the concept of the agricultural management bodies and CFBCs in Japan. The agriculture management body consists of the family management bodies and the organizational management bodies. The individual management bodies and the individual household cooperatives belong to the family management bodies while the organizational management cooperatives and the non-cooperate organizational management cooperatives belong to the organizational management bodies. Among these, individual household cooperatives and organizational management cooperative can be regarded as CFBCs. There are two types of CBFCs in general: incorporated cooperatives (in Japanese: *Hōjin*) (also known as juridical person) (ICBFCs) and non-incorporated cooperatives (in Japanese: *Hihōjin*) (also known as non-juridical person) (NCBFCs). Until 2017, there were a total of 15,136 CBFCs across the country. Among these CBFCs, the number of ICBFCs was 4,693 (MAFF, 2015).

In this study, the author only focused on ICBFCs, which are authorized by law with duties and rights and is recognized as a legal person and as having a distinct identity. ICBFCs have their own characteristics in maintaining and promoting local agriculture, which aim to collectively take care of agriculture in the community and increase farm income by reducing costs and expanding the scope of agricultural businesses (Hisano et al., 2018). They are not only

9 Hiroshima Prefectural Government, https://www.pref.hiroshima.lg.jp/soshiki/81/1170807500404.html

incorporated as land collections from individual farms but also are cooperatives that characterize the relationship with the community or future agriculture management.

In this chapter, the individual farm households and ICBFCs were targeted because they are the chief agent actors in doing agriculture and maintaining farmland in the study region. On the local scale, people's opinions allow us to know the actual situation of the FLA. And a bottom-up approach can also be developed to help the government design policies related to the FLA. To understand the management of ICBFCs also provide rich information to help work against FLA and managing local agriculture in the future. The main objectives of this chapter are as follows:

(1) To demonstrate the role of individual farm households in managing the FLA and local agriculture

(2) To demonstrate the role of ICBFCs in managing the FLA and local agriculture

(3) To investigate and discuss future countermeasures of the FLA

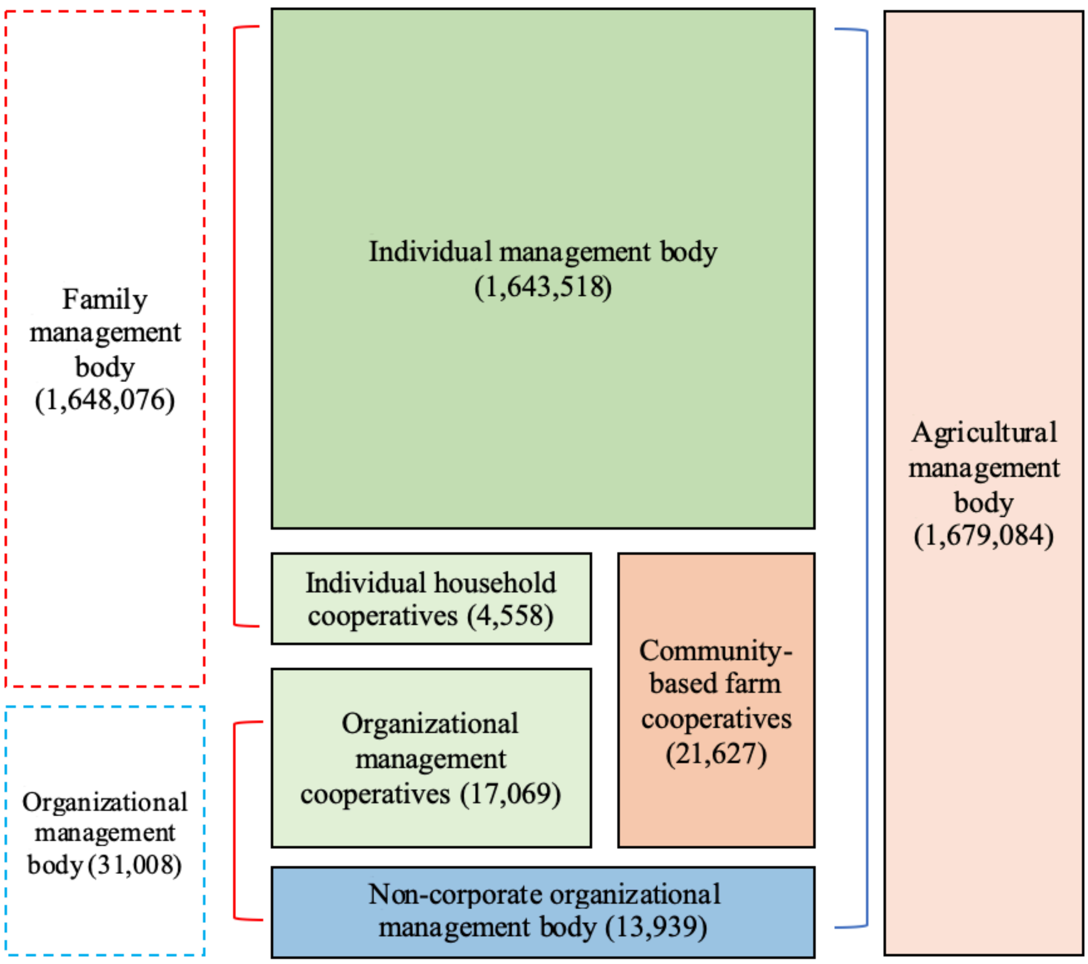

Figure 5-1 The concept of agricultural management body in Japan

Source: *MAFF (2010), Agricultural and Forestry Census.*

5.1 Local Scale FLA and Individual Farm Households

From the national or regional scales, the issue of FLA normally has been monitored on a macro scale, which allows us to understand its overall situations globally. However, on the local scale, FLA and its determinants, which are closer to the actual situation such as its occurrence, surrounding environment, local traditions, culture, and histories can be revealed. Such information also cannot be quantified and easily assessed by agricultural census data. For instance, some indispensable determinants of FLA, such as damages from wild animals, and agricultural policy changes have been found that also played key roles. Therefore, FLA should be explored on a local scale to support a better understanding of these issue.

5.1.1 Characteristics of FLA at the local scale

As have already introduced earlier, Hiroshima Prefecture has the highest FLAR in Japan until 2018. The characteristics of FLA in this region provide us rich information to understand the local scale FLA. Figure 5-2 clearly displays the FLAR at the former municipalities' level and the transportation conditions in Hiroshima Prefecture. We can easily understand the accessibility of different municipalities from Figure 5-2 as well. Municipalities colored in red refer to FLAR over 40%, and those colored in blue stand for places where FLAR is below 10%. The spatial distribution of FLA in Hiroshima Prefecture has distinctive characteristics, and the north and south have different patterns. High FLAR areas are mainly located in the southern Hiroshima Prefecture chiefly on coastal and the small island areas. In contrast, the northern (Kitahiroshima, Akitakada, Miyoshi and Shobara cities) and central parts (Sera city) of Hiroshima Prefecture still have a low FLAR.

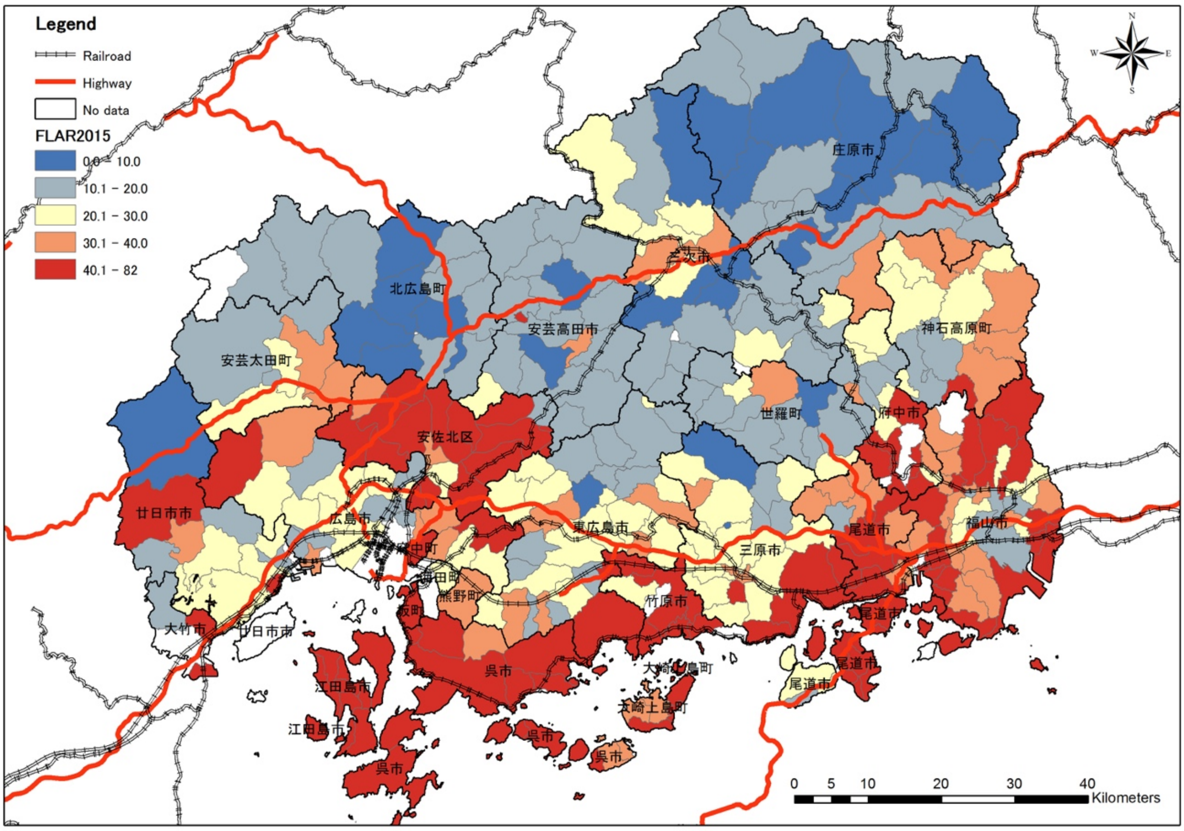

Figure 5-2 FLA and transportation condition in Hiroshima Prefecture

Source: *MAFF.*

5.1.2 Individual farm households and FLA

Whether to abandon farmland is usually the decision of individual farm households (Zhang et al., 2014). While socio-economic and spatial data are increasingly helpful to quantify and locate the extent and costs of land-use change, there is still little understanding of the contextual or local-specific factors that determine or influence the farmers' decision of abandoning farmland or not (Nkonya et al., 2016). To fully examine the behavior and effort of individual farm households in agriculture is thus of great significance to explain FLA at the local context. As Figure 5-3 shows, in Japan, farm households usually consist of business farm households and self-sufficient farm households. There also exist land tenure non-farm households, which indicates households that own farmland but do not engage in any agricultural activities. Business farm households are divided into full-time farm households[10] and part-time farm

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10 A farmer who does not have any part-time workers (persons who have been employed for more than 30 days a year and engaged in work or engaged in self-employment other than agriculture) among household members.

households[11] or into main farm households[12], semi-main farm households[13] and side farm households[14]. The proportions of full-time farm households and main farm households are is 20.8% and 8.3%, respectively. These numbers are relatively small compared to the total number of farm households.

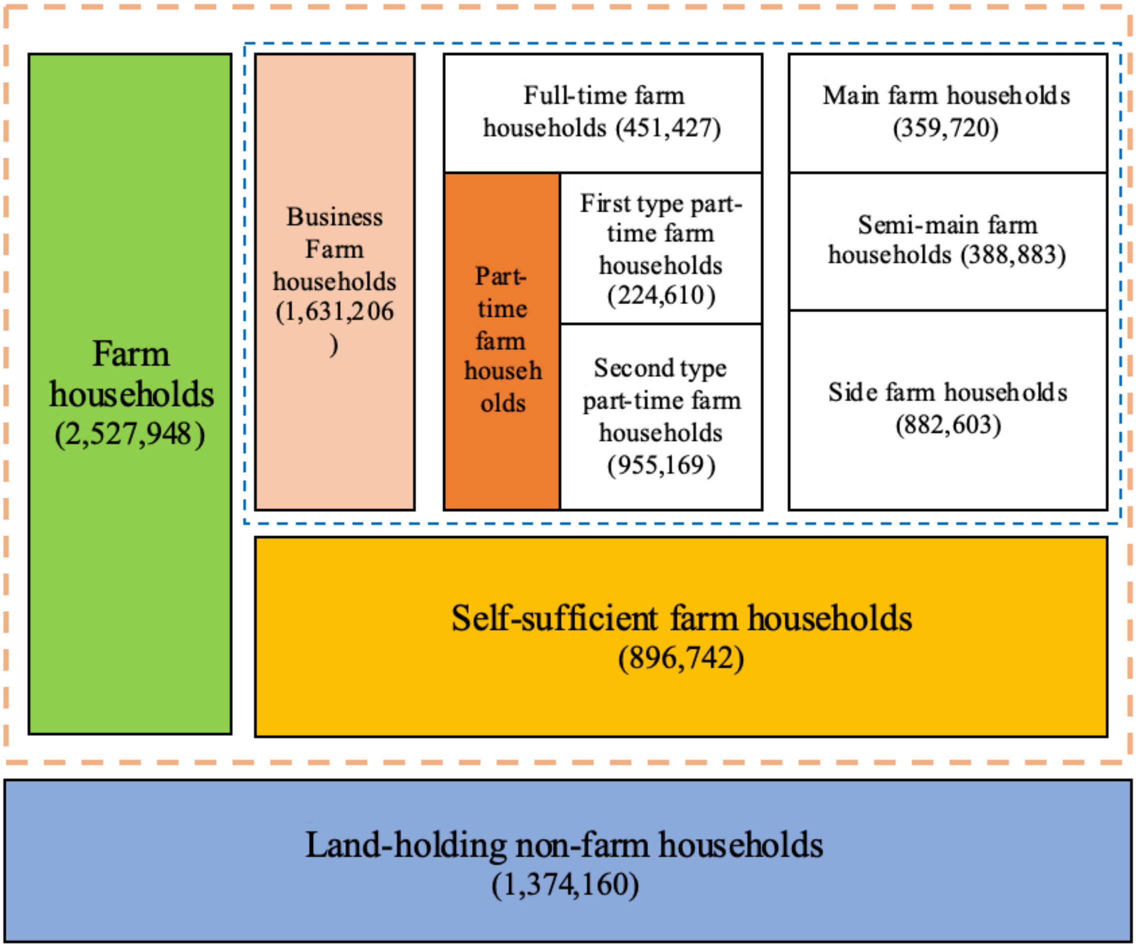

Figure 5-3 The concept of farm household in Japan

Source: *MAFF (2010), Agricultural and Forestry Census.*

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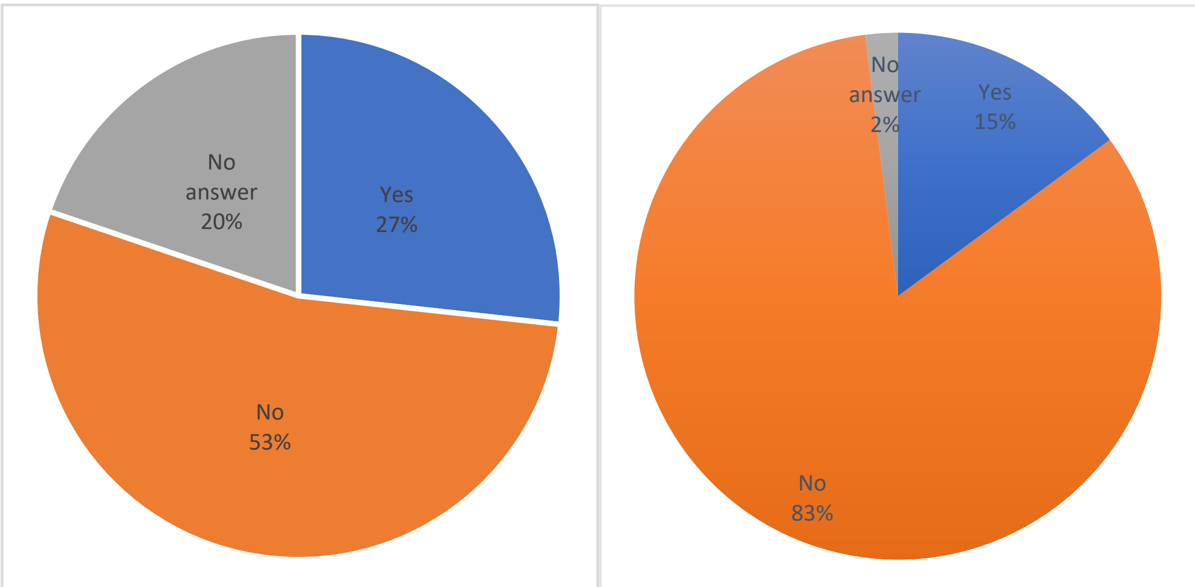
[11] Farmer with one or more part-time workers among household members.

[12] Farmers with household members under the age of 65 who are mainly engaged in self-employed agriculture for 60 days or more per year, with mainly agricultural income (more than 50% of farm income).

[13] Farmers with household members under the age of 65 who are mainly non-farm income (less than 50% of farm income) and are engaged in self-employed agriculture for 60 days or more per year.

[14] Farmers with no household members under the age of 65 who are engaged in self-employed farming for 60 days or more per year (farmers other than main and semi-main farmers).

To comprehensively understand the relationship between FLA and individual farm households on the local scale, two surveys were carried out in Sera town, Hiroshima Prefecture (details have been introduced in 2.2.3). In the first, the targeted groups were visitors who came to Sera roadside station (in Japanese: *Michinoeki*) and local individual farm households. First, the author randomly asked 101 people (not only local people, but also people who live in nearby cities who came to Sera roadside station for shopping) some questions about their awareness of FLA in Japan and their willingness to encourage their children to engage in agriculture in the future. Results suggested that just over half (53%) of the participants would not be willing to encourage their children to engage in agriculture while 27% people would encourage their children to engage in agriculture (Figure 5-4(a)). The answers imply that the future of agriculture is facing challenges with less people interested in farming activities. In Japan, it is common that the younger generations think agriculture is labor-consuming and boring, and this trend has caused many issues, such as FLA and a lack of successors in the agriculture sector (Yamashita & Hoshino, 2018). When asked about their awareness of FLA in most areas of Japan, 83% of respondents answered that they knew of this issue while only 15% of people knew little about FLA (Figure 5-4(b)).



(a) Willingness to engage in agriculture **(b) Awareness about FLA in Japan**

Figure 5-4 Local people's opinion on FLA(N=101)

The author also conducted a second survey to evaluate households' opinions of FLA and agriculture. Among 24 households from Sera town, Hiroshima Prefecture. First, the author asked farmers' primary purpose for engaging in agriculture. Eleven households responded that they just wanted to maintain the farmland which was inherited from their ancestors, and four households replied that they were engaged in agriculture for self-subsistence (Table5-1(a)). In Asian countries such as China and Japan, farmers regard their farmland as a treasure inherited from ancestors. As a result, farmers would rather abandon their farmland than transfer it to others (Li & Li, 2016). Thus, the respondents were passively engaged in agriculture with a low level of economic activities. Second, the author investigated the frequencies of children's help in agriculture. Seven households reported that their children helped them only at busy times, while five households had never received any labor support from children (Table5-1(b)). This could be the reason they had to build an organization, such as ICBFC, with other households, in order to share labor and management resources. Furthermore, the author asked some hypothetical questions about their future plans for abandoned farmland. Eight households answered that they would keep the current situation (being abandoned), and five households answered that they would look for someone else for cultivation (Table5-1(c)). The responses indicated that when actual abandonment happened, farmers can hardly take any countermeasures against FLA.

Table 5-1. Questionnaire survey results of individual farm households: (a) Main purpose for engaging in agriculture (N=17), (b) Frequency of children' help (N=16), (c) Future plan of abandoned plots (N=14)
Source: *data from the questionnaire survey of this study.*

(a)

Opinions	Number of households
To get income from agriculture	2
To maintain the farmland inherited from ancestors	11
To self-sufficient	4

(b)

Opinions	Number of households
Frequently (more than 10 times per month)	1
Sometimes (1-2 times per month)	3
Only at busy times	7
Seldom	5

(c)

Opinions	Number of households
To keep the current situation (being abandoned)	8
To look for someone else for cultivation	5
To re-cultivate the abandoned farmland	No answer
To look for other possible utilization	No answer
Others	1

The second survey also suggested that the socio-economic conditions of farm households are the major determinants for FLA. The three main reasons for abandoning farmland include lack of successors (24%), lack of sufficient laborers (21%) and aging of the householders (17%) (Table 5-2). Compared with the geographical condition, the socio-economic situations of farm households are more vital for local farmers to prevent farmland from being abandoned. Generally, in rural Japan, transportation and accessibility are well maintained, which satisfies farmers' requirements to do farming. With regard to preventing future FLA, farmers suggested that to lease farmland to households that have sufficient laborers (38%) and strong community-based farming (37%) would be effective in countering FLA (Table 5-3). In this respect, the results also support the hypothesis that ICBFCs are effective components in HMAs for promoting agricultural development and alleviating FLA. The next section focuses on ICBFCs and examine their contributions to managing local agriculture and FLA.

Table 5-2. The main reasons of FLA in the region (N = 17)

Reasons	Percentage (%)
Lack of agricultural successors	24.0
Lack of sufficient labor	21.0
Damage from wild animals	9.0
Far distance of farmlands	0.0
Low profit of agriculture	10.0
Accessibility of agriculture machine	7.0
Small size of farmlands	7.0
Elderly of farmers	17.0

Source: *data from the questionnaire survey of this study.*

Table 5-3. The possible solutions for re-cultivating abandoned farmland (N =17)

Solutions	Percentage (%)
Every farm household should work harder	6.0
Building of community-based agriculture	37.0
More subsidies from the government	19.0
Leasing of farmland to other households	38.0

Source: *data from the questionnaire survey of this study.*

5.2 The Role of ICBFCs in Managing FLA and Local Agriculture

To demonstrate the current situations and future plans of ICBFCs is significant for dealing with FLA and maintaining local agriculture. As has already been mentioned in the introduction, both CSA or CBA could be the future direction of farming or agriculture for countries which are facing serious labor issues. CSA or CBA models allow the producer and consumer to share the labor and risks of farming (Ryan, 2003). ICBFCs are established by well utilizing local-community resources and creating new values through local business; these are essential means of preserving local development (Peredo & Christman, 2006) and they largely deal with labor shortage caused by aging and depopulation. As such, ICBFCs also try to realize integrated management of agricultural resources, which attempts to optimize, over the long-term, rural society's benefits and acts as a promising countermeasure for sustainable development as well. The establishment of ICBFCs in Japan can be traced back to 2000 when the Japanese government adopted a comprehensive strategy for rural agriculture development and aimed to improve rural living and producing conditions. The current administration emphasizes the "corporatization" (in Japanese: *hōjinka*) of the agricultural sector as being an opportunity to revitalize the economically backward peripheries, and to prepare agriculture for international competition (Jentzsch, 2017). The number of ICBFCs in Hiroshima Prefecture is increasing year by year, reaching 275 by 2018. Their spatial distribution is highly in accordance with the agriculture resources and historical traditions of community-based farming in the municipalities (Figure 5-5). The biggest number of ICBFCs was highly concentrated in the central areas of Hiroshima Prefecture such as Sera town, Mihara city and Higashihiroshima city. The northern parts like Kitahiroshima, Akitakata, Miyoshi and Shobara cities also have more ICBFCs than the southern cities such as and Hiroshima, Kure, and Takehara cities. Coastal areas have less numbers of ICBFCs due to the small number of cropland and low accessibility.

In the study, the author believed that ICBFCs are not only for maintaining local agriculture but can also have the functions of alleviating the trend toward FLA. So far, most previous studies on FLA focuse on individual farm households and their behavior; FLA has not been well understood and evidenced from a local-community perspective. Scholars have suggested that farm household decisions are an essential domain to measure the drivers or determinants of FLA. Nevertheless, although there are many articles on the methodologies used to predict ideal farmland conservation based on the optimization of management resources, there are few studies that model farming activities and development of ICBFCs that could improve labor conditions and maintain local agriculture. This chapter tries to evaluate the function of ICBFCs to manage regional agriculture and mitigate FLA comprehensively. The case in Japan (with many ICBFCs to work against FLA and promote agriculture, especially in rural areas) can be an excellent example for understanding the setting and development of ICBFCs. Such innovative ideas could also have significant meaning in managing future FLA and promoting agriculture in other countries of the world. Such development might prove a promising way to deal with FLA in the future.

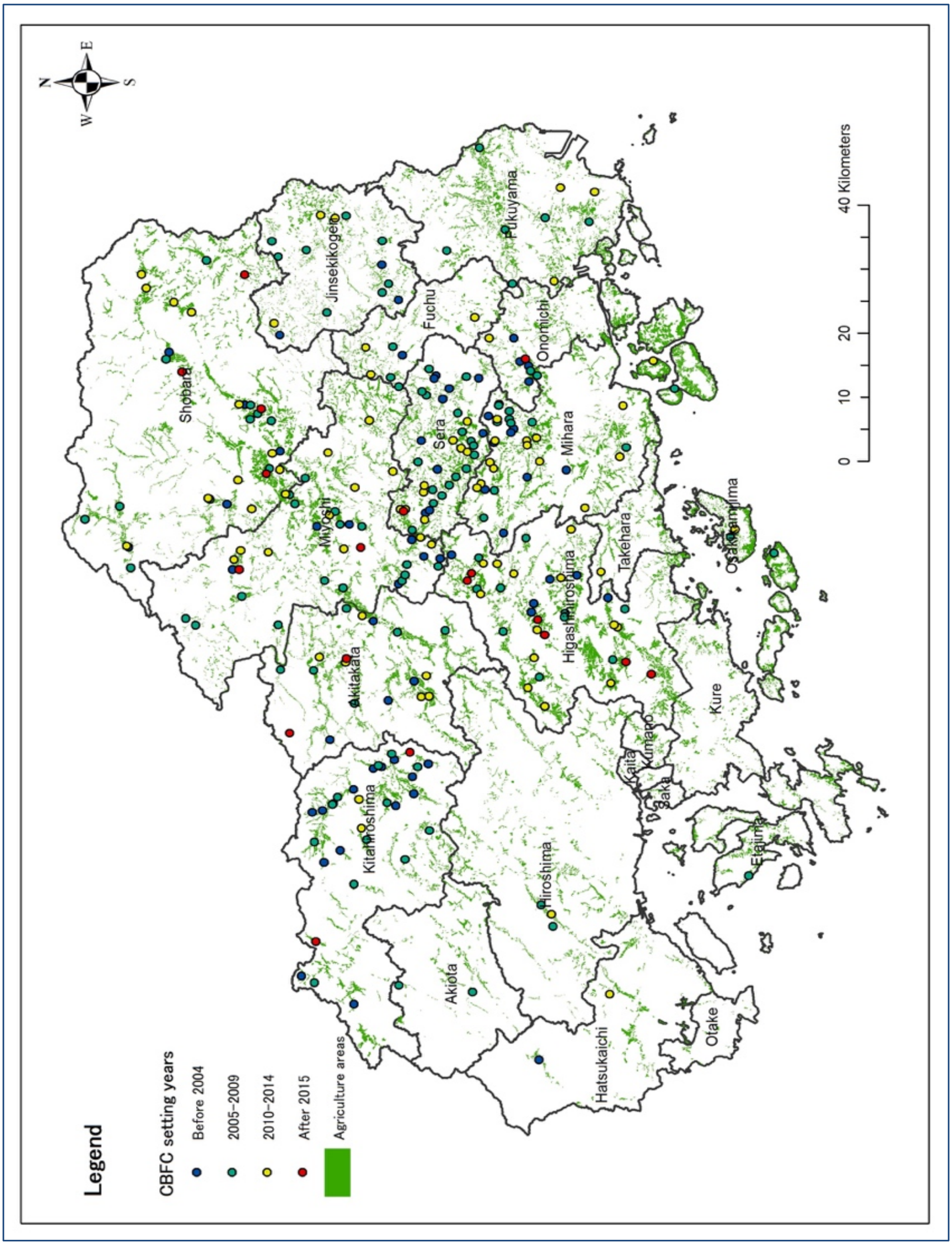


Figure 5-5 Spatial distribution of ICBFCs and agriculture areas in Hiroshima Prefecture

Source: *Hiroshima Prefectural Government, https://www.pref.hiroshima.lg.jp/site/english/*

5.2.1 Classification of ICBFCs

Based on the two surveys, the author analyzed the business situations of ICBFCs. As shown in Table 5-4, there are great differences in Hiroshima Prefecture ICBFCs' types and household participation. Overall, 57.5% of the ICBFCs are categorized as all farm household participatory type: most of all farm households in a specific area joined for conducting agriculture activities and manage their farmland. The remaining ICBFCs, 28.5% are of the large farm households' participatory type: only large farm households participated in the ICBFCs. 14.0% of ICBFCs belong to other types including companies or those managed by volunteer farm households. The average number of farm households that participated in ICBFCs is 36 and the average participation rate in ICBFCs is 65.9%. Such results suggest that more than half of farm households participated in ICBFCs to conduct agriculture and contribute in large part to the agriculture development in the municipality.

Table 5-4. Basic information of ICBFCs in Hiroshima Prefecture

Description		**Value**
Type (N=168)	1 All farm households participatory type (全戸参加型)	57.5%
	2 Large farm households participatory type (担い手中心型)	28.5%
	3 Others	14.0%
Average farm household participated in ICBFCs (N147)		36
Average rate of ICBFCs in the municipality (N=102)		65.9%

Source: *data from the questionnaire survey of this study.*

Table 5-5. clearly displayed the information and business statues of three ICBFCs (K, S and P) in Hiroshima Prefecture. K was established in 2009 and the business scale was not big in terms of farmland areas. In contrast, the scales of S established in 2010 and P established in 2015 were much bigger. It can be observed that the three ICBFCs share some similarities in regard to their management. First, the agriculture is centered on rice production. although many ICBFCs have been making a efforts to sell processed and value-added products, such as flower cultivation (Imai et al., 2008). Second, ICBFCs basically own some agricultural machines, which allows them to improve their productivity and working efficiency. Third, ICBFCs heavily relied on subsidies from government to help with their management.

Table 5-5. Examples of ICBFCs in Hiroshima Prefecture

Name of the ICBFC		**K**	**S**	**P**
Type		All farm households participatory type (全戸参加型)	Large farm households participatory type (担い手中心型)	Others, farm company (株式会社)
Year of establishment		2009	2010	2015
Households number		13	57	43
Member information	Male	7	8	5
	Female	7	1	6
	Employer	4	9	10
Farmland information	Paddy field (ha)	12	32	19.3
	Cropland (ha)	0.9	2.1	4.3
	Fruit land (ha)			0.2
Location		Sera town	Akitakada city	Higashihiroshima city
Expenditure in 2018		10,970,000	32,270,000	15,200,000
Sales in 2018		11,006,000	36,400,000	13,360,000
Agricultural machines		Tractor (4), Rice planting machine (3), combine harvester (3)	Tractor (3), Rice planting machine (1), combine harvester (2), cultivator (6), boom sprayer (1)	Tractor (3), Rice planting machine (1), combine harvester (1), cultivator (1)
Subsidies		DPS, 2014-2019 2,000,000/year	No information	DPS, 2016-now 2,080,000/year
Attitude to FLA		Negative, it will become a hiding place for birds and beasts, and it is a source of disaster and flood damages	Negative, with the trend of depopulation and aging, it become difficult for re-cultivation of abandoned farmland	Positive, FLA is a by-product of the *adjustment of rice production* policy, and currently there is no need to worry about it.

Source: *data from the questionnaire survey of this study.*

Table 5-6 presents the farmland condition and member information of three types of ICBFCs in Hiroshima Prefecture. For farmland conditions, the majority of ICBFCs responded that they have paddy fields with an average area of 33.78 ha. Type 1 ICBFCs have an average of 55.9 ha paddy field. Cropland is not dominant in most ICBFCs, which have an average area of 2.2 ha. The average fruit field areas are 12.9 ha. Regarding members' age, 46.3% of ICBFC members are aged over 70 years old, and 33.5% of ICBFC members are aged between 60 and 70 years old. The aging issue in ICBFCs is also serious.

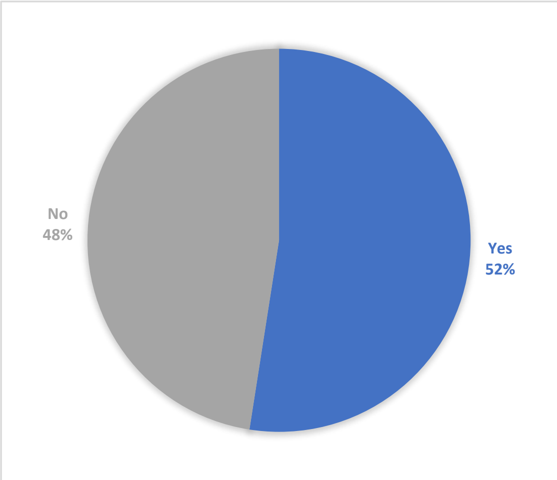
Table 5-6. Farmland area and members

		Total	Type 1	Type 2	Type 3
Farmland	Average area of paddy field (ha)	33.8	55.9	26.8	22.1
	Average area of cropland (ha) (N = 45)	2.2	2.1	1.2	4.1
	Average area of fruit field (ha) (N = 17)	12.9	21.5	0.8	0.6
Members Age	Below 30 years old (people)	0.8%	22	9	7
	30-40 years old (people)	1.5%	55	9	4
	40-50 years old (people)	5.0%	222	18	7
	50-60 years old (people)	13.0%	576	13	26
	60-70 years old (people)	33.5%	1417	55	51
	Over 70 years old (people)	46.3%	1885	45	219

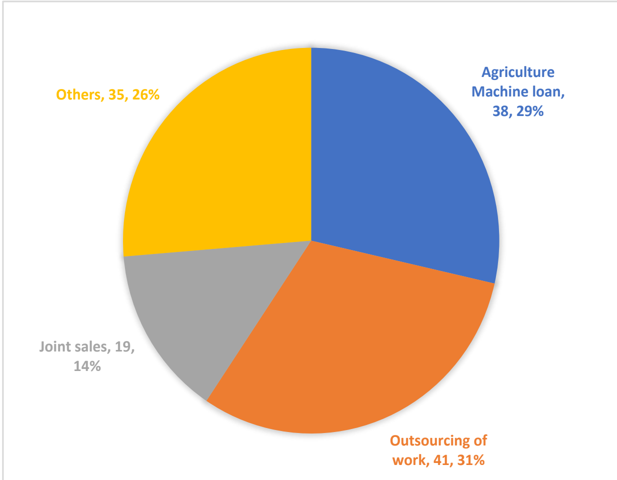
Source: *data from the questionnaire survey of this study.*

5.2.2 How do ICBFCs contribute to the management of local agriculture?

ICBFCs can contribute to the agriculture development through building connections and developing intensive management to improve workers' skills through workshops or trainings. As previously discussed, the author focused on ICBFCs instead of individual farm households because ICBFCs have played a key role in local agriculture development, especially in rural areas. On the one hand, ICBFCs can strengthen connections and communications among local farmers to enhance the information sharing (Figure 5-6 (a)). From the survey, approximately half (52%) of the ICBFCs answered that they cooperate with other ICBFCs. Outsourcing of work and agriculture machine loans are the most common cooperation they engage in (Figure 5-6 (b)). On the other hand, ICBFCs could help local farmers to improve their skills by sharing information such as holding seminars or workshops. More than half of the ICBFCs reported that they have held workshops, and 45% of ICBFCs had workshops 1-3 times a year (Figure 5-7). The themes of workshops also varied among ICBFCs and include measures against damage by wild animals (26.4%), new agriculture technologies (23.6%) and management skills (20.1%) are the most expecting themes (Table 5-6).



(a)



(b)

Figure 5-6 Connections among ICBFCs (N=162)

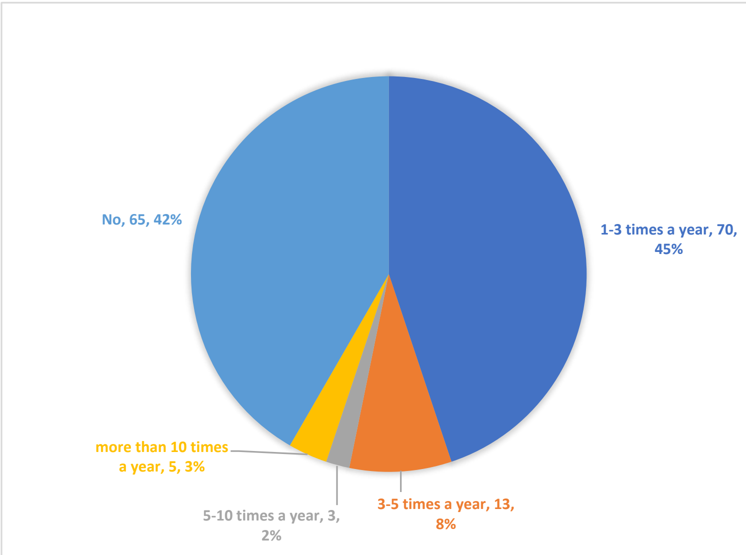


Figure 5-7 Frequency of holding workshops (N=162)

Table 5-7. The theme of workshops (N=162)

Themes	Percentage (%)
Agriculture technology	23.6
New items (brand)	4.3
Management skills	20.1
Measures against wild animal damages	26.4
Sales (marketing, logistics)	7.1
Production and quality control of agriculture products	17.0
Others	1.6

Source: *data from the questionnaire survey of this study.*

ICBFCs have implemented some measures for maintaining local farmland. The installation of fences to prevent wild animal damages is the most common measure that they have implemented (34.7%). In addition, cultivation of multiple crops other than rice (23.7%) and environmentally friendly initiatives such as pesticide-reduction cultivation and organic farming (19.5%) is in progress (Table 5-7).

Table 5-8. Measures that ICBFCs have implemented for maintaining local farmland? (Select the most important three answers)

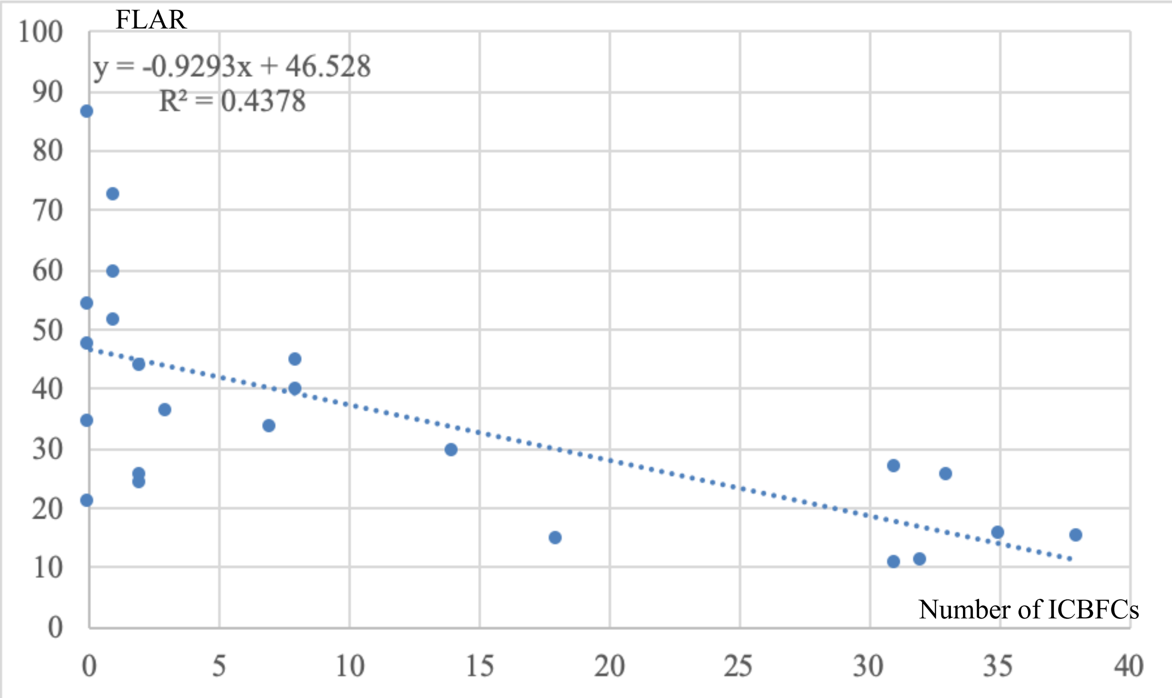
Measures	Percentage (%)
Reduced pesticide or organic farming	19.5
Cultivation of various crops other than rice	23.7
Cultivation of landscape crops	7.2
Installation of fences to avoid wild animal damage	34.7
Combined management and six industrialization	10.9
Others	10.0

Source: *data from the questionnaire survey of this study.*

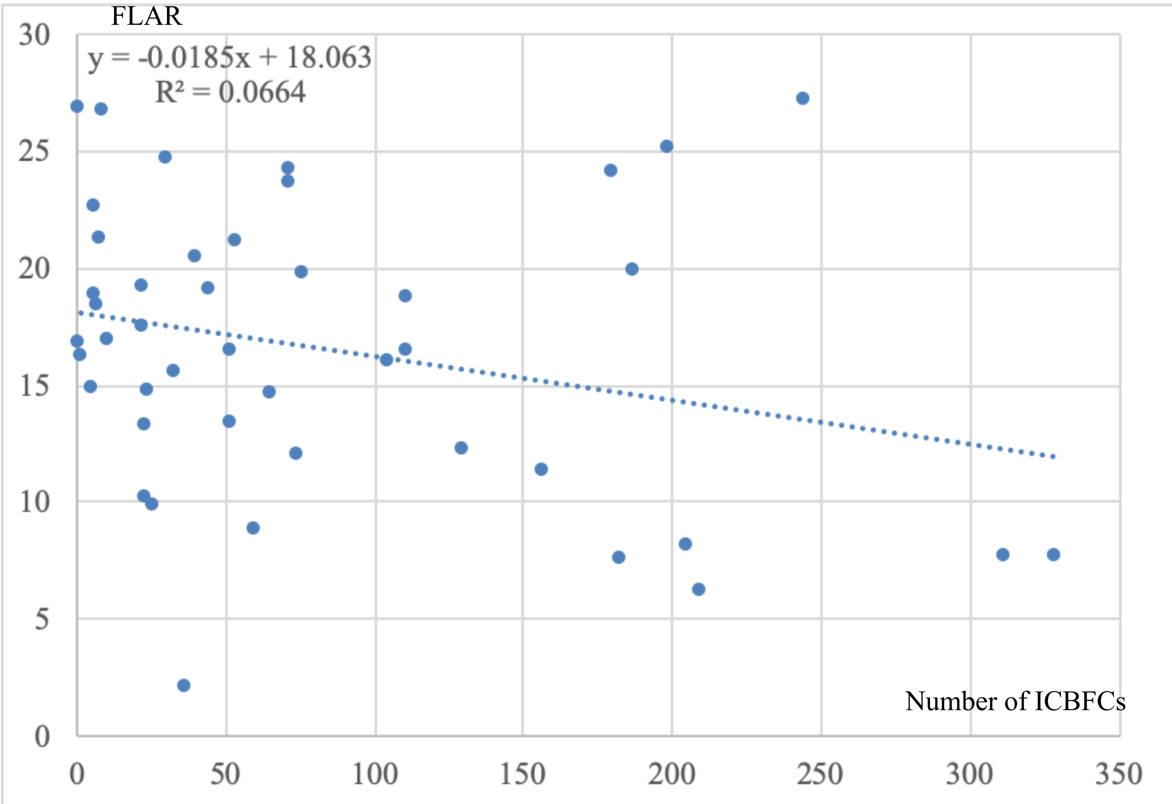
5.2.3 How do ICBFCs contribute to the prevention of FLA?

At the municipalities level, the number of ICBFCs and FLAR were inversely correlated, which indicated that ICBFCs could help to reduce FLA.

In order to investigate the relationship between the number of ICBFCs and FLA, the author calculated the number of ICBFCs and FLAR for each city in Hiroshima Prefecture (Figure 5-8 (a)) and each Prefecture in Japan (Figure 5-8 (b)). The correlation between the number of ICBFCs and FLAR at city level in Hiroshima Prefecture implies that ICBFCs have played an active role in countering FLA ($R^2 = 0.44$) (Figure 5-8 (a)). By contrast, the correlation between the number of ICBFCs and FLAR at Prefecture level in Japan does not exhibit a strong relationship compared to city level ($R^2 = 0.07$) (Figure 5-8 (b)). On the one hand, it is thought that the relationship between the numbers of ICBFCs and FLA is not strong at the level of the Prefecture. The reason is because the factors that affect FLA, such as topographical conditions and agricultural structures, varied widely among Prefectures. On the other hand, by comparing the data of each municipality on a prefectural basis, the influence of topographical conditions and agricultural structures will be reduced. As such, the relationship between ICBFCs and FLA appears much stronger (Yabiki, 2015).



(a)



(b)

Figure 5-8 Correlation between FLAR and number of ICBFCs (a. Hiroshima city level; b. National prefectural level)

Source: *MAFF.*

ICBFCs collected farmland from farm households and made great efforts to promote local agriculture and to preserve farmland. In Hiroshima Prefecture, about 16% of ICBFCs reported that they have owned abandoned farmland (Figure 5-9). The number is not a large ratio and most ICBFCs only lease well-conditioned farmland from farmers. However, when there is FLA, most ICBFCs lack effective countermeasure to deal with this process. It is also difficult for ICBFCs to re-cultivate the abandoned farmland or to utilize it effectively. ICBFCs with FLA also answered that they would keep the abandoned farmland in its current condition or as grassland and forest land (Table 5-8). Some ICBFCs also mentioned they were regularly mowing on abandoned farmland to avoid damages from wild animals and maintain the possibility and potential for re-cultivation. Of ICBFCs, 28% answered that they had experiences of re-cultivating abandoned farmland: the average area for re-cultivation is 1.97 ha.

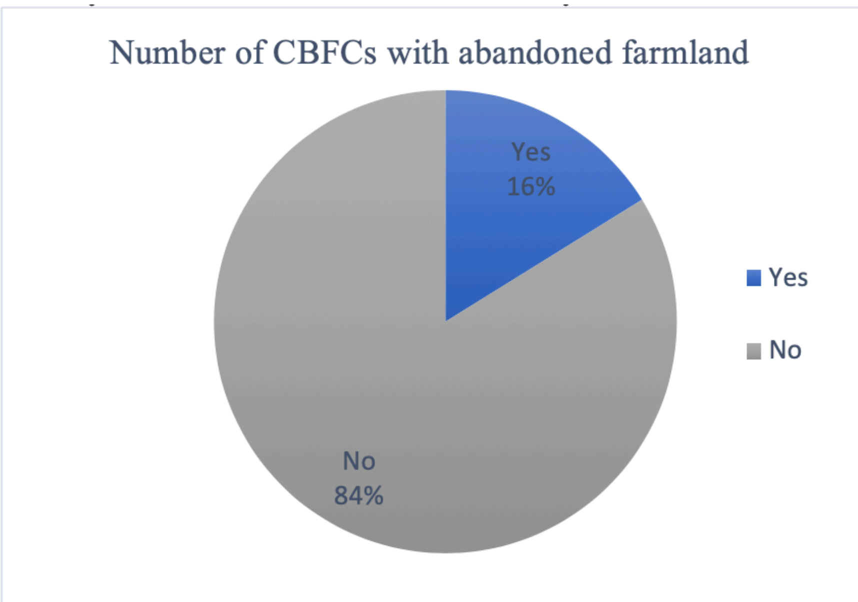


Figure 5-9 Ratio of ICBFCs that owned abandoned farmland (N=167)

Table 5-9. Actions been implemented for abandoned farmland in ICBFCs

Restrictions	Percentage (%)
For grassland or forest land	25.0
For preventing from wild animal damages	10.4
For being watered	8.3
For landscape crops	8.3
For keeping current situation	25.0
Others	23.0

Many restrictions hinder the re-cultivation of abandoned farmland in ICBFCs. The most challengeable restrictions for re-cultivation came from financial situation (33.9%) and labor condition (23.4%) with 42 and 29 ICBFCs responses, respectively (Table 5-9). Regardless of whether they have owned abandoned farmland or not, the author also asked ICBFCs for their opinions on FLA. 90 % of ICBFCs argued that FLA is a problem. Giving the reasons such as that abandoned farmland will destroy the landscape and will transfer into habitat of wild animals easily. The most common reasons for FLA in the region are lack of successors (17.7%), aging of farmers (17.3%) and the low profit of agriculture production (13.3%) (Table 5-10). For both Type 1 and Type 2 ICBFCs, lack of agricultural successors and aging of farmers are the most crucial restrictions. For Type 3 ICBFCs, the lack of agricultural successors became more critical than the aging of farmers.

Table 5-10. The restrictions for re-cultivating abandoned farmland

Restrictions	Percentage (%)
It costs more money	33.9
It costs more labor	23.4
Ownership of abandoned farmland is unclear	8.1
Abandoned farmland is too dispersed	8.9
New ideas are indispensable	15.3
Others	10.4

Source: *data from the questionnaire survey of this study.*

Table 5-11. The most important reasons for FLA in the region?

(The most important three answers selected)

Reasons	Percentage (%)	Type 1	Type 2	Type 3
Depopulation	8.1	8.3	7.3	8.9
Lack of agricultural successors	17.7	18.0	15.9	17.8
Lack of enough labor	10.6	10.4	10.1	13.3
Damage of wild animals and birds	10.8	10.4	14.5	8.9
Farmland is too far away	0.5	0.3	1.5	0.0
Low profit of agriculture	13.3	13.5	13.0	11.1
Bad accessibility of agricultural machines	7.0	6.1	8.7	11.1
Small size of farmland	12.2	12.5	10.1	13.3
Aging of farmers	17.3	18.0	15.9	2.9

Others	2.5	2.5	2.9	2.2

Source: *data from the questionnaire survey of this study.*

ICBFCs also proposed some possible countermeasures against future FLA. The three types of ICBFCs were suggested in order to prevent or re-cultivate future FLA; the government should pay more subsidies to support agriculture (28.0%); the community-based farming scheme should be developed (24.0%); and farmland should be leased to households with sufficient labor (10.9%) (Table 5-12).

Table 5-12. Effective countermeasures to mitigate further FLA

(The most important three answers selected)

Countermeasures	**Percentage (%)**	**Type 1**	**Type 2**	**Type 3**
Individual farm household should put more effort	13.4	12.3	21.6	9.7
Developing more ICBFCs	24.0	25.0	19.6	22.6
More help from households with sufficient labor	4.3	4.5	0.0	9.7
Government should pay more subsidies	28.0	28.0	29.4	25.8
More help from people in other industries	9.7	10.1	5.9	12.9
Leasing of farmland to households with sufficient labor	10.9	10.8	13.7	6.5
Others	9.7	9.3	9.8	12.9

Source: *data from the questionnaire survey of this study.*

5.3The Future Direction of ICBFCs and FLA

In response to the weakening of agriculture, the Japanese government updated its law for sustainable agricultural practices to the Basic Law on Food, Agriculture and rural Areas, which began to be enforced in 1999. This law was necessary for promoting agricultural production that remains in harmony with the environment without compromising food security, thereby leading to a healthy development of agriculture. The law aims to stabilize and improve people’s lifestyle and to develop the economy through comprehensively and systematically implementing policies on food, agriculture and rural areas by means of establishing basic principles (MAFF, 2015). Recently, policymakers in Japan have focused their attention on improving the competitiveness of the agricultural sector by initiating some direct payment programs to larger farms, as well as reforming land regulations to make it easier for farms to increase in size (OECD, 2009). In relation to farmland with unclear ownership which is common for public projects and consolidation of fields and forested areas, the government set out the policies which make it available for establishing a farmland registration system and the state of land ownership (Ministry of Land, Infrastructure & Land, 2018).

In the past two decades, Japan's government formulated two most important policies to adjust the structure of and revitalize agriculture such as the adjustment of rice production (in Japanese: *Gentan seisaku*) (Matsuno et al., 2006) and the direct payment scheme (DPS) (in Japanese: *Chokusetsu Shiharai*) (Ito et al., 2019). The adjustment of rice production has been in place since the 1970s to encourage farmers to switch crops to a demand-oriented production and to diversify the use of agricultural land. Eventually, this policy maintained the price of rice in the face of overproduction (D. Takahashi, 2015; Kobari, 2018). DPS was initially set up to highlight and enhance the agricultural multifunctionality in HMAs, and, to assist in addressing the challenges of aging and depopulation, limited non-farm employment, and the deterioration of the living environment (Ito et al., 2019).

Regarding those two policies, ICBFCs exhibited very distinct opinions on them (Figure 5-10). 35 out of 157 ICBFCs replied that the adjustment of rice production is effective and 34 and 28 thought it had little or no effect. The adjustment of rice production that has been in place since 1970 is facing some challenges. The Government wants to terminate this policy in order to build a free-competition environment for farmers, and they are seeking a more practical approach to maintaining farmland. Compared to the adjustment of rice production, DPS indicated a much stronger effect. 106 out of 157 ICBFCs supported this scheme and think it was very effective. In contrast to the European context, this fund is paid to ICBFCs instead of directly to individual households. Despite receiving the subsidy, a large number of ICBFCs is still facing financial problem. The effectiveness of the DPS that was initiated in 2000 to prevent FLA or encourage re-cultivation should also be optimized. In addition, the DPS should also consider intraregional agricultural characteristics to avoid negative effects of subsidies that support farm businesses under a rapidly changing farm environment (Iba, 2010). For instance, the DPS needs to develop a spatially explicit, regionally specific subsidy system that targets different crops or farming structures. As such, promoting the development of smart agriculture and structural reform to address FLA will be more effective.

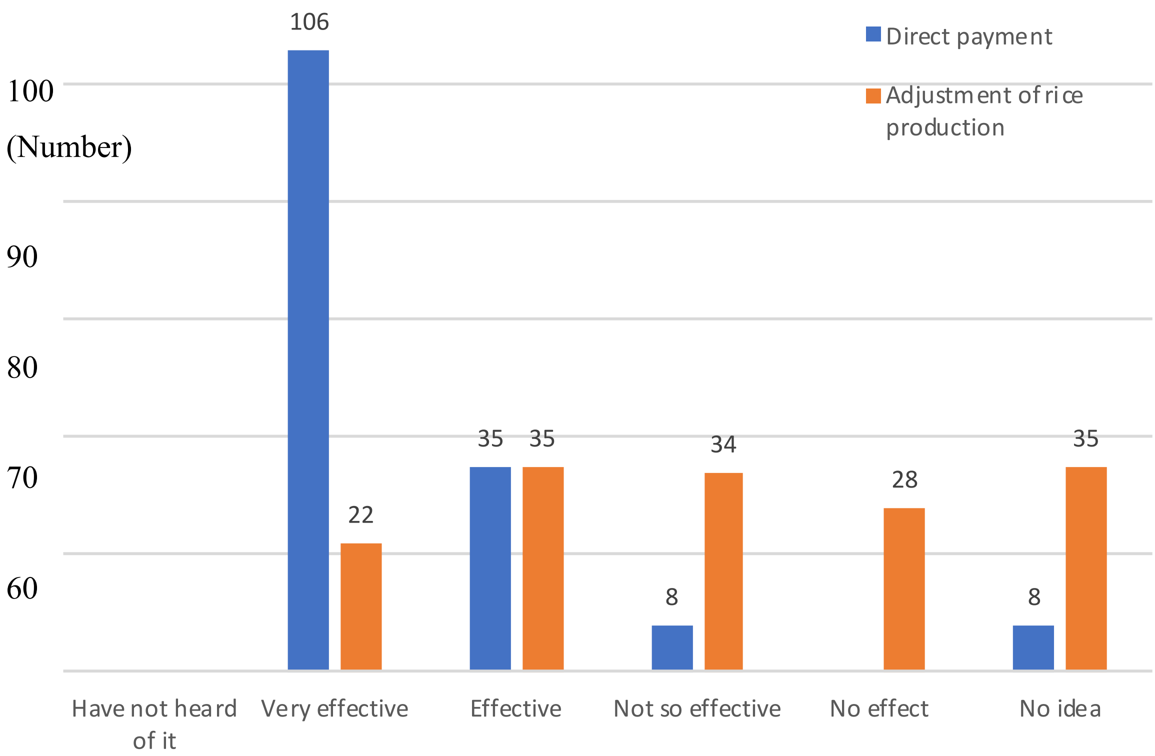


Figure 5-10 Opinions on DPS and "Adjustment of rice production" by ICBFCs in Hiroshima Prefecture. (N=157)

ICBFCs have played an active role in maintaining local agriculture and farmland with various advantages. The most apparent advantages for ICBFCs include working efficiency, which is improved by large-scale mechanized agriculture (25.4%), the effects of working against depopulation (23.1%), and agricultural cost reduction (19.6%) (Table 5-12).

Table 5-13. The merits for setting ICBFCs

Merits	Percentage (%)
It is easier to secure labor than individual farmers	11.4
Reduce agricultural costs	19.6
Work against depopulation	23.1
FLA mitigation and farmland management	14.5
Active farmers' connection	4.2
Work efficiency is improved by large-scale mechanization	25.4
Others	1.8

Source: *data from the questionnaire survey of this study.*

Regarding of the future development of ICBFCs, there are many challenges and much potentials. On the one hand, for the future development, most ICBFCs want to improve their financial situation (19.1%), to utilize advanced technologies to help agriculture (19.1%), and to cultivate various crops other than rice (17.7%) for future development. For type 3 ICBFCs, combined management and *six industrialization* has received the most answers (19.4%) (Table 5-13). On the other hand, regarding the future challenges, lack of human resources and successors (24.4%), the increase in the number of elderly people (20.1%), and uncertainty of future of agricultural policies (15.6%) are the most significant concerns with regard to future challenges. The survey results indicate that 59.2% of ICBFCs have successors, while 27.4% of ICBFCs do not have any heirs (Table 5-14). In some other areas, training for successors has already been conducted, and it seems to be easier to find a successor for a ICBFC than for an individual farm household (Takeo et al., 2014).

Table 5-14. Future development plan of ICBFCs

(Select the most important three answers)

Future plan	Percentage (%)	Type 1	Type 2	Type 3
Reduced pesticide or organic farming	14.9	15.1	14.3	13.9
Cultivation of various crops other than rice	17.7	18.0	17.1	16.7
Cooperation with local universities or research institutes	4.0	3.2	4.3	11.1
Combined management and six industrialization	12.5	12.0	11.4	19.4
Maintaining good relationship with non-ICBFC farmers	7.1	6.3	11.4	5.6
Financial improvement	19.1	19.6	18.6	13.9
Utilization of advanced technologies to help agriculture	19.1	20.5	18.6	8.3
Others	5.6	5.4	4.3	11.1

Table 5-15. Challenges for the future development of ICBFC

(Select the most important three answers)

Future plan	Total Percentage (%)	Type 1	Type 2	Type 3
Lack of human resources and successors	24.4	25.1	19.7	24.4
Increase in the number of elderly people	20.1	22.0	10.6	20.0
Burden of maintenance cost	3.4	2.5	6.1	6.7
Inconvenient for transportation and shipping	1.1	0.3	4.5	2.2
Management dependent on government subsides	11.3	12.1	9.1	8.9
The future of agricultural policies is unclear	15.6	15.8	18.2	11.1
Unstable price of agricultural products	12.0	11.3	15.1	13.3
Inefficiency of agricultural work due to dispersion of farmland	3.8	2.5	9.1	6.7
Increase of people who are innocent to ICBFC management	6.6	7.3	3.0	4.4
Others	1.5	0.8	4.5	2.2

Source: *data from the questionnaire survey of this study.*

5.4 Discussion of Findings

The establishment and development of ICBFCs can promote the future management of FLA and local agriculture. The flow chart in 5-11 depicts the flowchart of how ICBFCs work to promote FLA management and local agriculture. On the one hand, ICBFCs contributed greatly to the prevention and management of FLA. For the municipalities with larger numbers of ICBFCs, the FLAR is lower, as the survey results indicated. The socio-economic condition, such as lack of labor and successors, and aging farmers in farm households or ICBFCs are more prone to affect the FLA trend. On the other hand, ICBFCs promoted local agriculture development mainly through building connections among ICBFCs and farm households, which can improve information sharing; by intensive management of agriculture and share resource or labor which can maximize profit; or by implementation new technology, such as organic farming and utilization of high technologies (drones, robots, AI).

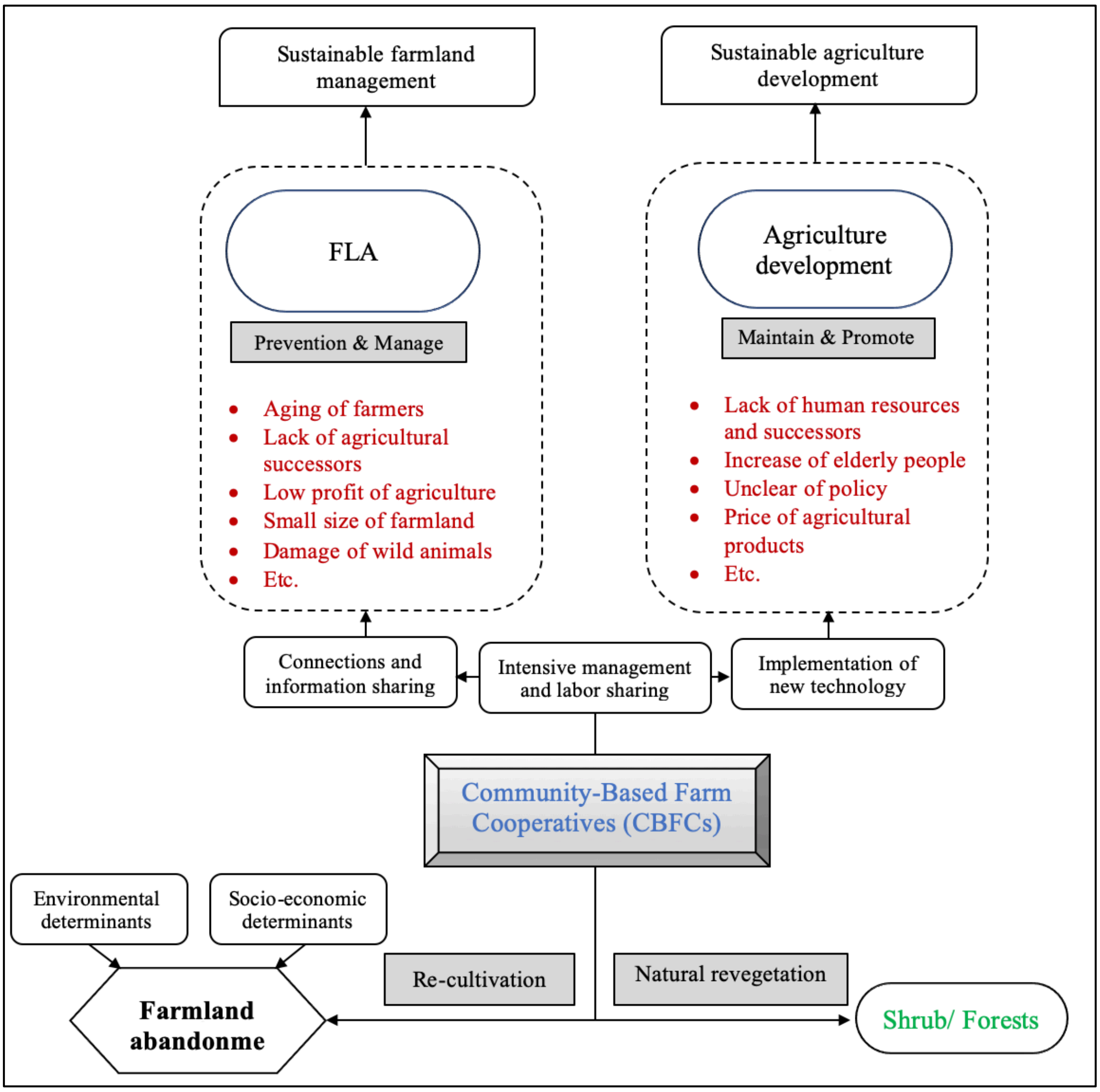


Figure 5-11 How do ICBFCs contribute to management of FLA and local agriculture

Source: *Author.*

5.5Summary of Findings

In Japan, the development of ICBFCs is an essential strategy for rural restructuring and improving the efficiency of agricultural production. This chapter has presented the opinions of individual farm households and ICBFCs regarding FLA and has investigated their contributions to local agriculture development. The findings imply that the ICBFCs have played a significant role in ensuring local agriculture development and working against depopulation and lack of labors. For the future development, ICBFCs should be encouraged and could be a promising countermeasure for FLA.

The major findings of this chapter are as follows:

First, the three main reasons for local farm households to abandon their farmland are: lack of successors, lack of sufficient laborers, and aging of farmers. For ICBFCs, the major determinants are lack of successors, aging of farmers, and low profit from agriculture production.

Second, most farm households and ICBFCs exhibited a negative attitude to the future FLA. An inverse correlation between FLA and ICBFCs at the municipality level suggested ICBFCs do have an effective role in preventing FLA. In addition, more financial support from the government is required to manage future FLA.

Third, labor conditions are more significant for individual farm households while the economic situation of ICBFCs is the key to solving for FLA. Similarly, for future countermeasures against FLA, individual farm households are more concerned about labor conditions, and ICBFCs regard the financial situation as more significant.

Fourth, ICBFCs can mainly contribute to agriculture development in two regards. ICBFCs can strengthen connections and communications among local farmers; and agriculture skills can also be improved through periodic workshops. On the other hand, ICBFCs can also improve the working efficiency and ensure the adequacy of labor conditions by intensive management.

Finally, regarding future development, financial and labor conditions are key issues for sustainable ICBFC management. Many ICBFCs also expressed a desire for mutual support from the government and farmland management organizations. Meanwhile, they also expect more of the young generation to return to the rural areas (Lutz et al., 2017).

CHAPTER 6 DISCUSSIONS AND CONCLUSIONS

This research aimed to investigate the issue of Farmland Abandonment (FLA) in Japan, including its spatial and temporal patterns, determinants, and countermeasures. The study focused on the national, intraregional, and local scales for explicitly explaining the issue of FLA in Japan, and then finally to reveal its mechanism. Based on an introduction of research background regarding both historical and theoretical aspects, literature review, research aims, scope and framework, the significance of the study was fully elaborated (Chapter 1). Then, a preview of the study area and data has been presented and discussed. Especially, the three scales in this study were significant for conducting research and revealing the mechanisms of FLA comprehensively (Chapter 2). FLA at the national scale of its spatial and temporal patterns, determinants and regional variations were displayed and discussed. (Chapter 3). From the intraregional scale, the correlation between agricultural characteristics and FLA has been examined and demonstrated, findings offered a new perspective to explain the process of FLA (Chapter 4). FLA at the local scale by selecting individual farm households and (Incorporated Community-Based Farm Cooperatives) ICBFCs was explored (Chapter 5). The results at each specific case allow us to have a comprehensive understanding of FLA. The lessons learned from the findings enhanced the understanding of FLA, its intraregional differences, and prevention of FLA by making better farmland use suggestions. Which also supported to have some future recommendations for the better management of FLA and agriculture development in Japan and to the world.

In this chapter (Chapter 6), first, the author discusses the mechanisms of FLA in Japan and the findings of the FLA at each specific scale are summarized under the research objectives. Especially, the author discusses whether the findings reached the objectives and how the study contributes to the objectives. Second, the current policies on FLA and agriculture are reviewed and discussed. Some of the critical findings assist in forming explicit policy implications for both central and local government. Third, the session is about the suggestions and thoughts regarding current FLA in Japan and its future development, which contains the suggestions for farmers, ICBFCs. Additionally, the limitation of this study and future research recommendation are provided. Finally, the last part is the discussion and future direction of this study. How to well utilize and interpret the research results into actual FLA and agriculture management in Japan are discussed. The results also provide farmers some suggestions about FLA and future agriculture development.

6.1 Discussions on FLA in Japan

From the national scale, similar to other countries, FLA in Japan is also primarily driven by socio-economic factors. In recent years, socio-economic strategies are likely to be integrated into agricultural management and related projects, which will change the existing businesses according to social issues, and redefine resource development and value chains (Kataoka, 2018). As heavily depopulated especially in rural areas, Japan has an unfavorable socio-economic condition of agriculture, which adversely promotes the increase of abandoned farmland. From a national scale, FLA in Japan is due to its subsistence farming. The high share of self-sufficient farm households and land tenure non-farm households promote the process of FLA. After the higher economic period, due to the aging and depopulation in Japan, elderly farmers lack sufficient labor and rely on mechanization while young people have lost their passion for agriculture, and thus the conversion of farm households from commercial to self-sufficient was expected. From the result, the arable land ratio of self-sufficient farm households exhibited the most significant positive effect. It seems that there are limited commercial activities for elderly farmers to engage in agriculture or farming, or many of them engage in agriculture for their own living, thereby increasing the likelihood that farmers will abandon their farmland when encountering difficulties. In addition, monocropping of rice also led to FLA, especially, cropland and fruit fields contributed the most to abandonment. Japanese agriculture is centered around rice cropping, where rice paddy fields are essential components of agriculture, accounting for 54.3% of the total arable land area (Rudel et al., 2005). However, paddy field areas are declining, partially due to policies such as the adjustment of rice production (Matsuno et al., 2006). However, numerous farm households, especially self-sufficient households, were not willing to change their land to other crops, and this policy became ineffective. The result also showed a negative correlation between the paddy field density and FLAR in most regions, which indicated that paddy fields are easy to maintain, and farmers are fond of rice farming. Monocropping is unfavorable for agriculture in many regions because it might be vulnerable to keep agriculture sustainability. How to change people's consciousness and diversify the use of farmlands remain future challenges for the Japanese government and society. Lastly, agriculture in Japan relies heavily on subsidies (George-Mulgan, 2004). For instance, a direct payment scheme was issued since 2000 in HMAs to maintain farmland and revitalize agriculture (Grədinaru et al., 2015). In contrast to the European context, this fund is paid to community-based farming unions instead of directly to individual households (Jentzsch, 2017). Many areas ill-suited to agriculture depend heavily on these two subsidies; hence, the approaches were not effective at maintaining the farming of good-quality agricultural land. Thus, the situation brought little benefit to agricultural development, and it was not effective in preventing the expansion of abandonment.

From the intraregional scale, FLA correlates with intraregional agricultural characteristics of a region. Until 2018, the Chugoku and Shikoku region experienced the highest FLAR in Japan, and the driving forces behind this trend are complicated. Since 1979, the One Village One Product (OVOP) scheme, initially adopted in Oita Prefecture, has been in place in Japan as an idea for regional agriculture revitalization. Also influenced by the OVOP scheme, agricultural characteristics in the Chugoku and Shikoku region display great diversity. The OVOP movement advocated for the sales of products that best represent the locale, thereby generating income and improving the local economy (Schumann, 2016). Agricultural characteristics, such as products, scale, and labor conditions, were improved to fit local situation. From PCA, 8 PCs were identified in our study to describe the intraregional characteristics of agriculture in the Chugoku and Shikoku region and each PC displays significant spatial variations. This diversity is reflected in an explicit intraregional division among farming areas. The MLR models display higher explanatory power for flatland farming areas and intermediate farming areas than for the other two areas. From intraregional scale, in flatland farming areas and intermediate farming areas where agriculture is more stable and easier to maintain, the causes of FLA are more influenced by changes in agricultural characteristics than geographical conditions. For the urban areas and mountainous farming areas, the MLRs exhibit lower explanatory power than for the other two areas. The land use situations are more complex in urban areas, where factors such as urbanization could have a stronger influence on FLA (Ruskule et al., 2013). In contract to this, in mountainous farming areas, because the effect of altitude on agricultural tends to be non-linear, small changes in altitude and slope matter more than low-lying areas (Yamaguchi et al., 2016).

From the local scale, FLA is influenced chiefly by socio-economic condition of local agricultural stakeholders such as farmers or ICBFCs. Table 6-1 concluded the determinants of FLA and opinions of future development of individual farm households and ICBFCs. For the main determinants of FLA, both individual farm households and ICBFCs stated that lack of successors and aging of farmers were the two important variables; this corresponds to many previous findings (Yamashita & Hoshino, 2018; O'Rourke, 2019). The issue of lacking successors is not only a challenge for the individual farm households but for the future development of ICBFCs as well. For individual farm households, a lack of laborers is an important determinant because if they engage only in their family's agriculture, ensuring enough labor will be difficult, while for ICBFCs, the low profit in agriculture production becomes vital as they are trying to maximize their profit. This is following the bid rent theory and farmland that have good condition have been preserved. Regarding the management of FLA, both individual farm households and ICBFCs think that remaining the current condition (being abandoned) is the best solution. ICBFCs also conducted seasonal management such as mowing and building fences in the abandoned farmland. Such measures can protect the farmland from wild animal damages and ensure the farmland is easily re-cultivated in the future. For the future management of FLA, leasing of farmland to households with sufficient labor is more essential for individual farm households, while having greater subsidies from the government to support agriculture strikes is most essential for ICBFCs. Both of individual farm households and ICBFCs mentioned that to develop a CBA scheme is a promising countermeasure for FLA in the future.

Table 6-1. Comparison of individual farm households and ICBFCs

	Individual farm households	**ICBFCs**
The main factors affecting FLA	Lack of successors Lack of sufficient laborers Aging of farmers	Lack of successors Aging of farmers Low profit of agriculture
How to manage current abandoned farmland	To keep the current situation (being abandoned) To look for someone for help Others	To keep the current situation Transfer into forest or grass land Others
Suggestions for managing future FLA	Lease farmland to households with sufficient labor Community-based farming More subsidies to support agriculture	More subsidies to support agriculture Community-based farming Lease farmland to households with sufficient labor

6.2Summary of Findings

6.2.1 Spatial and temporal patterns of FLA in Japan

The spatial and temporal patterns of FLA in Japan suggest the diverse development of agriculture due to the variations in the country's geographical condition as well as agricultural characteristics.

Spatial patterns of FLA in Japan are uneven, and different regions exhibit different extents of FLA, which strongly correspond to regional geographical conditions and agricultural development. On national scale, it can be recognized that most abandoned farmland is concentrated in the Chugoku and Shikoku, Kanto, Kyushu, and Chubu regions, in contrast to other regions that have good agricultural conditions, such as the Hokkaido and Tohoku regions. On the intraregional scale, it can be noticed that FLA happened in most HMAs and island areas where are not suitable for agriculture production. Farmland in coastal areas also has a higher possibility of being abandoned and exhibits a higher FLAR than inland areas, such as in Tohoku and Kyushu regions. In regard to the local scale, FLA has been chiefly observed in the mountainous areas far away from major transportation systems. Farmland in small size and narrow shape is also easily becoming abandoned plots.

Regarding the temporal patterns of FLA in Japan, the trend of FLA is increasing nationally with more and more abandonment every year. A national-scale FLAR and their temporal variations from 2005 to 2015 imply that this trend increased from 9.66% in 2005 to 12.14% in 2015. A prefectural wise FLA tells us that most Prefectures observed an increase of FLAR, while only a few Prefectures have decreased in this trend. In 2005, the highest FLAR was observed in Nagasaki Prefecture with 27.13%; Yamanashi and Gunma Prefectures followed with values of 23.41% and 20.86%, respectively. In 2015, the highest FLAR was observed in Hiroshima Prefecture, with 27.14%, followed by Yamanashi and Nagasaki Prefectures, with values of 26.85% and 26.72%, respectively.

6.2.2 Determinants of FLA

Determinants of FLA are usually complex and can be interpreted from different scales. From the findings, the determinants of FLA are summarized in Table 6-2. On the national scale, the overall situation of FLA and its determinants has been examined. In general, household-related variables, such as the arable land ratio of self-sufficient farm households, displayed the most significant positive correlation with FLA; non-successor farm households were also positively correlated with FLA. In contrast, the arable land area per farm household and the laborers per farm household were negatively correlated with FLA. For farmland-related variables, paddy field density exhibited a significant negative correlation with FLA. In addition, determinants of FLA are spatially varied according to local geographical or socio-economic circumstances. Different variables in global regression displayed different explanatory ability in local regressions. FLA is caused by complex processes driven by interactions of multiple determinants. Even within one region, the determinants might be different depending on specific local circumstances.

On the intraregional scale in the Chugoku and Shikoku region, the results revealed a significant correlation between agricultural characteristics and FLA. Variables selected to measure the agricultural characteristics in the study region can explain nearly 52.8% of the variations of FLA. The sales orientation and scale of agriculture have the strongest negative correlation to FLA in the region, while the status of agricultural succession displayed the strongest positive correlation to FLA. The high FLA in the Seto Inland Sea areas is chiefly due to the low profit of fruit production and the changes of the market prices. In flatland farming areas and intermediate farming areas, where agriculture is more stable and easier to maintain, FLA is more strongly influenced by changes in agricultural characteristics than by geographic conditions such as slope or altitude.

On the local scale, most farm households and ICBFCs expressed a major concern to FLA for future agriculture development. The main reasons of FLA with farm households are lack of successors, lack of sufficient laborers, and aging of farmers. For ICBFCs, the major determinants are lack of successors, aging of farmers and low profit of agriculture production. ICBFCs can contribute to the prevention of future FLA and agriculture through intensive management and connection building. For the future development of agriculture, the labor condition is more significant for individual farm households while the economic situation of ICBFCs is the key to deal with FLA.

Table 6-2. Different determinants of FLA and their influences at three scales

Scale	Determinants	Influence
National	Arable land ratio of self-sufficient farm households	+
	Non-successor farm households	+
	Arable land area per farm household	-
	Laborers per farm household	-
	Paddy field density	+
	Slope of farmland	+
Intraregional	The sales orientation and scale of agriculture	+
	The status of agricultural succession	-
	The fruit production agriculture	+
Local	Lack of successors	+
	Aging of farmers	+
	Low profit of agriculture	+
	Lack of sufficient laborers	+
	Development of ICBFCs	-

+ refers to positive influence; - refers to negative influence

6.2.3 Countermeasures of FLA

Regarding countermeasures and suggestions to prevent further abandonment, both the government and farmers should be well informed of the issue and formulate effective actions toward FLA.

On the one hand, for the farmers or farm households, the Japanese government should introduce some new policies or taxation reforms to assist farm households, especially self-sufficient farmers, to re-cultivate their land or to allow them to easily transfer their farmland to agricultural cooperatives that have sufficient laborers. For individual farmers and non-successor farm households, in order to solve the lack of labor, strengthening community-based farming, and more cooperation of farmers and people in other industries to support agriculture could be effective solutions to prevent FLA. Leasing farmland to households with sufficient labor is essential for individual farm households, while receiving more financial support from the government to support agriculture is most relevant for ICBFCs.

On the other hand, the prevention of FLA should also consider farmland management. Rice and paddy fields have played significant roles in agriculture development in Japan and paddy field density exhibited a positive influence on FLA. Therefore, the high tariff on imported rice is vital in keeping paddy fields in Japan. As such, policies regarding the rice market are crucial for promoting agriculture and maintaining farmland. Unclear of farmland ownership is striking in rural areas, and there is a large amount of hidden abandonment[15] in Japan. The government should try to identify such farmland and build a farmland sharing system, such as farmland banks (Jentzsch, 2017), to encourage the formation of networks for farmland transition and sharing.

6.3 Policy Implications

For better management of agriculture and FLA, policies should take the national, intraregional, local variations, uneven patterns of FLA and agricultural characteristics into account. First, policymakers should pay more attention to the management of agricultural areas, especially abandoned farmland, giving due consideration to the potential for natural regeneration and the historical values of the farmland when dealing with FLA. Second, ICBFCs and large-scale agriculture management bodies in Japan (Ichikawa, 2011) that are playing an increasingly active role in maintaining local agriculture and mitigating FLA should be encouraged and supported. They usually collect farmland from nearby individual farm households in the municipality using contractual arrangements and help farmers manage their farmland effectively. Both the central and local governments should provide more support socially and economically to help the management of such big scale farming. Third, for small farmers and farm households who lack in laborers, the consolidation and leasing of their farmlands to larger ICBFCs could be a promising way to maintain their farmlands. For instance, it is necessary to concentrate and intensify farmland through the operation of the Public Corporation for Farmland Consolidation (Hoshino, 2001) to core farmers by renting and leasing. The local government and policies should encourage more young generations to return to rural areas and engage in agriculture. Finally, the coexistence of small-scale farm households and large-scale

[15] Hidden abandonment or semi-abandonment is farmland where agricultural production ceases, but the land is maintained as cultivated farmland. Hidden abandonment is between cultivated and abandoned land, which has a high risk of being abandoned in subsequent years (Grədinaru et al., 2015).

management bodies in the farming sector is significant for the future sustainable development of agriculture and farmland (Shimizu, 2017).

In general, the government should put more focus on this issue and try to prevent further abandonment. In view of various local and global needs, Japan should develop agriculture into a vigorous industry. Here the author provided some policies implications from the three scales:

Implications on the national scale

- Farm household structures are essential to promoting agriculture development. The large shares of self-sufficient farm households and land tenure non-farm households are unfavorable for future agriculture development. Policies should allow farmland transition procedures to be more flexible.
- There are regional differences in the FLA determinants due to the different of regional conditions. Therefore, future agriculture policies should pay attention to such variations and promote agriculture suited to local conditions.
- Encourage young generations to come back to agriculture and become agriculture successors in the future.
- Be careful to institute new policies while considering different crops, especially for rice.
- To stabilize farm income and consideration of the income insurance for agriculture.
- Taxation adjustment for FLA.

Implications on the intraregional scale

- Intraregional variations and uneven patterns of agricultural characteristics are vital for the management of FLA.
- Scale of agriculture and access to the market are essential points to secure regional agriculture development.
- Proper zoning and scale-setting of farmland will be important to stabilize the farming workforce, especially in rural areas.

Implications on the local scale

- Building of connections among community-based farming and farmers is crucial for maintaining agriculture.
- Providing guidance and training in agriculture and management are primarily welcomed by ICBFCs.

- Financial support to the ICBFCs and labor support to the individual farm households.
- Bottom-up approach to address the issue of FLA

6.4Future Recommendations for FLA and Agriculture

6.4.1 What is the future of FLA in Japan?

Over the years, the problem of FLA has been challenging many developed countries and is becoming a serious issue in developing countries. However, regarding the future development of FLA, there is no agreement from the global. Regarding the questions on the future direction of FLA in Japan, there is no clear answer, and the optimum path to manage FLA still needs to be explored further. The process of FLA seems irreversible, but this development can be controlled and alleviated in the future. Based on the results and findings from this research, the author offers some insights for the future management of FLA.

The process of FLA in Japan can be explained by both the theory of forest transition and bid rent which clearly present the transitions among different land. For the future management of FLA, two aspects should be considered.

On the one hand, for farmland that is located near mountains or in the mountainous farming areas (Figure 4-10), to transfer into the natural forest and maximize the ecological value will be more beneficial than re-cultivation. In Japan, some scholars also think it is advisable to combine abandoned farmland and grass pastures in order to ensure the maintenance of grazing capacity for farmland that is full of grass (Koyama, 2004). For example, the fruit production areas in the Seto Inland Sea coastal areas have been abandoned in the past 10 years. The government should make clear initiatives either to re-cultivate the farmland or to convert them into natural forestland in the future.

On the other hand, for farmland that are still with high agricultural values, farmers and the government should put more effort to re-cultivate the farmland. The government should make a comprehensively evaluation system in respect to FLA in different regions and under different circumstances. For example, in Europe, to evaluate the value of farmland (whether it is High Nature Value (HNV) farmland or not) based on some certain criteria and decide future uses has been introduced (Zakkak et al., 2015). This approach can be applied to Japan as well to take measures suitable to local conditions. In the future, Japan should also develop a sustainable farmland and agriculture management practices that contribute to the prevention of further FLA and building national resilience to future FLA.

6.4.2 Agriculture revitalization and sustainable development

This research has analyzed the problem of FLA from different scales and angles, and the findings are significant for instructing future management of agriculture and FLA in Japan and other nations. For future agriculture development, the author insists that the securing of a healthy and sustainable agricultural structure is fundamental for dealing with FLA and maintaining agriculture development. As the first country in Asia entering the high-income stage (D. Takahashi, 2015), Japan should propose positive empirical analysis and policy recommendations for addressing the issue of FLA and agricultural development.

Finding a balance between the management of agriculture resource and economic development while still ensuring sustainable development is a key issue for both policymakers and the farmers (Xue et al., 2019; Tashiro et al., 2019). Japan Business Federation (in Japanese: Keidanren) is well aligned to proactively deliver on the United Nations' SDGs to end poverty, protect the planet, and ensure prosperity for all through the creation of Society 5.0 (Shiroishi et al., 2018). Society 5.0 (Figure 6-1) was proposed in the 5th Science and Technology Basic Plan as a future society that Japan should aspire to. The concept follows the hunting and gathering society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0). Among these, Society 2.0 demonstrates the agrarian society and its position in the process of society 5.0. Both the SDGs and Society 5.0 have emphasized the significance of agriculture in the process of social development and sustainability. Achieving Society 5.0 with these attributes would enable not only Japan but the world as well to realize economic development while solving critical social problems. It would also contribute to meeting the SDGs. In the Society 5.0 era, the function of the agriculture will not be weakened but should be revitalized and have special characteristics:

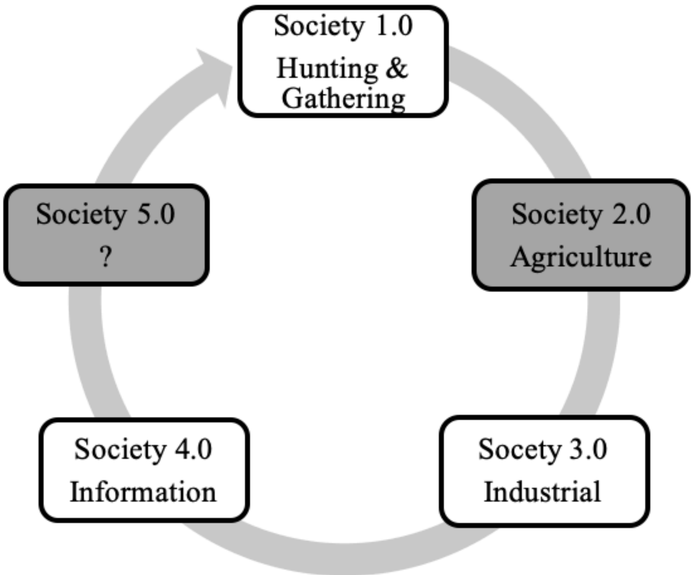


Figure 6-1 The conceptualization of the Society 5.0

Source: *Science and Technology Policy. Council for Science, Technology and Innovation.*

Advanced technologies and smart agriculture

From the author's perspective, in the process of reaching society 5.0, agriculture still plays a significant role, and future agriculture management can be accomplished by many advanced technologies in the face of FLA. Due to the trend of aging and depopulation, the Japanese government has spared no efforts to the revitalize of rural areas and agriculture. For example, to resolve the challenges that future agriculture development is facing, Japan is making progress in the introduction of smart agriculture technologies for productivity improvement, farming business size expansion, product quality improvement, skill transfers, and advanced agriculture business. The rapid growth of the new technologies that ICBFCs are currently utilizing, such as drone, robot and sensing, suggests an effective measure to prevent FLA and for future agriculture development. Meanwhile, promoting technology development for facility sharing and other cost-cutting initiatives will be significant as well, such as information sharing and communication distantly by using the Internet (Deng et al., 2019). Advanced technologies and smart agriculture will provide new ideas for farmers to manage FLA and agriculture.

Environmentally friendly agriculture

Development of an environmentally friendly agriculture that farmers can fully exert their potential capacities and find a new way for coexistence with the nature is vital for the future direction of agriculture. The issue of wild animal damage has been a long-standing problem in Japan (Lane et al., 1998), which adversely affects farmland and agriculture. From the surveys, most rural farmers are concerned about wild animal damages. They think FLA will become more serious because abandoned farmland provided a hidden habitat for the wild animals. Therefore, the author recommends that the management and planning of farmland affected by wild animal damages should focus on actions towards the balance of agriculture management and animal preservation. The coexistence of human and nature is the utmost goal for future development, which also contributes to the sustainability of agriculture.

In recent years, some people returned to rural areas and engaged in agriculture by conducting organic farming and environmentally friendly agriculture. They also target on abandoned farmland and try to re-cultivate such farmland. Compared to traditional agriculture practices, organic farming and agriculture can be more sustainable for both the environment and society.

Value added agriculture

Through value-added initiatives, agriculture production is becoming more prosperous and agriculture will be more vigorous. In rural areas of Japan, the sixth industrialization, which means that combination of agriculture, food processing, and retail to create new products by using fundamental agricultural products is progressing (Nakano, 2014). Such development can increase the consumption of the agricultural products and promote the participation of more rural residents in agriculture, improving the utilization rate of farmland. For the future development, value-added agriculture can be a promising way to not only benefit farmers economically but also will strengthen the social sustainability of farming communities. The issue of FLA will also be alleviated if agriculture can attract more people to engage in.

To the authors' knowledge this dissertation was the first study to thoroughly examine the process, spatial and temporal patterns, determinants and countermeasures of FLA in Japan. The results provided us an explicit understanding of FLA from the national, intraregional and local scales in Japan through both quantitative and qualitative aspects. The findings help to explain the mechanisms of FLA in Japan, suggesting better informed farmland use countermeasures to mitigate further abandonment. Such results also contribute to the understanding of FLA in the developed countries, promoting the maintenance of farmland and sustainable agriculture.

6.5Limitations

There are several limitations that the author could not address in the current study which are beyond the scope of the research. Future research can extend and further test the findings as some gaps remain in the knowledge around FLA and agricultural development.

First, the concept of FLA defined by MAFF only considers short-term abandonment and ignores long-term abandonment, which is a more stable and concise way to discuss abandonment. There is a significant amount of hidden abandonment, as previously discussed. These farmlands have been abandoned for years, which makes it challenging to decide the future utilization, either because of aging of farmers or a lack of successors (Yamashita & Hoshino, 2018). Future research can consider different types of abandonment when discussing FLA.

Second, due to the lack of enough data and time, many aspects of FLA determinants have not been adequately elaborated at the current stage. In the study, the author only considered data that is available from the agricultural census at former municipalities scale to evaluate FLA by a limited number of socio-economic variables. Although census data can correspond to former municipalities spatially in regression models, some important information such as rural-urban migration (E. Corbelle-Rico et al., 2012) or labor market (Xie et al., 2014) is still missing. Future research can consider different scales and variables related to these aspects, as well.

Third, for the methodology, we utilized both GWR and PCA to perform the analysis in interpreting both regional and intraregional variations of agriculture and FLA. Those two statistical tools share some similarities in their functions. This study only considers GWR from national scale and PCA from intraregional scale due to the sequence we conducted our analysis. Future research can also try to utilize PCA method at the national scale and extract new variables to explain FLA in Japan which might provide new perspectives.

Fourth, since FLA is a long and complicated process, further longitudinal research with period ranging from 30-50 years is needed for monitoring the dynamics of FLA. Understanding FLA at different stages will help to manage future abandonment more effectively. From the qualitative aspect, more in-depth interviews with farm households and ICBFCs should be conducted to confirm the findings of agricultural characteristics and FLA. This might illustrate how local traditions and cultural background (Ruskule et al., 2013), interact with agricultural characteristics to shape FLA.

Finally, many articles on farmland preservation and the rural landscape seek to address issues of sustainability (Czyzewski & Matuszczak, 2016), regionality (Sang et al., 2014) and environmental ecology (Parcerisas et al., 2012). As such, new localized approaches for the management of FLA and agriculture still need to be explored.

Despite these limitations, this research is a significant contribution to the understanding of FLA in east Asian and developed countries, which are experiencing the trend of aging and depopulation. The findings have provided a comprehensive explanation of the determinants of FLA and can support both farmers and the government to make better-informed decisions toward future agriculture management and FLA prevention.

Acknowledgements

Upon completion of this doctoral research, I would like to express my special gratitude to the Taoyaka Program for creating a flexible, enduring and peaceful society and MEXT, whose financial support allowed me to finish my doctoral degree smoothly.

First and foremost, I would like to give my greatest acknowledgement to my main supervisor, professor Kazuo TOMOZAWA for the 5-year continuous support of my Ph.D. study and related research. His patience, motivation, and immense knowledge helped me in all the time of research and writing of this dissertation. I could not have imagined having a better advisor and mentor during my study in Geography lab of Hiroshima University.

Also, I shall express my heartfelt appreciation to professor Hidenori OKAHASHI who has been my supervisor for three years, for his constructive advices and valuable suggestions on my research. He also motivates and cares for everyone's life in the lab with genuine patience and sense of humor.

The deepest gratitude should go to professor Huili GONG in Capital Normal University, China who had introduced me to Hiroshima University 5 years ago. His profound knowledge triggers my motivation for my study abroad and whose earnest attitude teaches me how to be an adorable researcher like him.

High tribute shall be paid to my sub-supervisors: professor Koji OKUMURA, professor Junyi ZHANG, associate professor Hideaki GOTO, associate professor Takuya GOTO and associate professor Yasuhiro KUMAHARA for their valuable comments and academic guidance on my research via advice seminars and supervisors' meetings. I am deeply grateful of assistant professor Lin CHEN, for his help in my study in Japan, and he is also acting as a wise friend in life. Special thanks go to Dr. Adina Staicov who spent her precious time to help me during the writing process of the dissertation. I would also like to thank all the tutors and staffs of the Taoyaka Program and Graduate School of Letters for their direct and indirect help to me.

Last but not the least, I am highly in debt to my parents in China, my father, my mother and my younger brother, for their unconditional support and sacrifice during the last 5 years. I am thankful to my friends and lab mates who have put considerable time and effort into their comments as well as language assistance. I would specially thank my heavenly father. It was he who gave me wisdom and patience to do whatever I did for his glory with all mighty. I keenly felt how important of my brothers and sisters from Chinese church who encouraged and supported me all the way to pursue my studies.

As a geographer, I strongly believe that “Travelling 1000 miles is as important as reading 1000 books”. It has been a wonderful and pride journey to have all these experience over the years. The precious time I spent in Hiroshima University will become one of my life-long memories. I sincerely appreciate everyone’s help and I shall be prepared for the next stages!

References

Abdi, H., & Williams, L. J. (2010). Principal component analysis. *Wiley Interdisciplinary Reviews: Computational Statistics*, *2*(4), 433–459. https://doi.org/10.1002/wics.101

Abson, D. J., Dougill, A. J., & Stringer, L. C. (2012). Using Principal Component Analysis for information-rich socio-ecological vulnerability mapping in Southern Africa. *Applied Geography*, *35*(1–2), 515–524. https://doi.org/10.1016/j.apgeog.2012.08.004

Aizaki, H., Sato, K., & Osari, H. (2006). Contingent valuation approach in measuring the multifunctionality of agriculture and rural areas in Japan. *Paddy and Water Environment*, *4*(4), 217–222. https://doi.org/10.1007/s10333-006-0052-8

Anselin, L. (1995). Local Indicators of Spatial Association—LISA. *Geographical Analysis*, *27*, 93–115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

Arika, E., & Mazure, G. (2017). Problems and Solutions for Abandonment of Utilised Agricultural Areas in Latvia. *Rural Development and Entrepreneurship Bioeconomy Production and Co-Operation in Agriculture*, (44), 307–314.

Balázs, B., Pataki, G., & Lazányi, O. (2016). Prospects for the future: Community supported agriculture in Hungary. *Futures*, *83*, 100–111. https://doi.org/10.1016/j.futures.2016.03.005

Baumann, M., Kuemmerle, T., Elbakidze, M., Ozdogan, M., Radeloff, V. C., Keuler, N. S., … Hostert, P. (2011). Patterns and drivers of post-socialist farmland abandonment in Western Ukraine. *Land Use Policy*, *28*, 552–562. https://doi.org/10.1016/j.landusepol.2010.11.003

Beilin, R., Lindborg, R., Stenseke, M., Pereira, H. M., Llausàs, A., Slätmo, E., … Queiroz, C. (2014). Analysing how drivers of agricultural land abandonment affect biodiversity and cultural landscapes using case studies from Scandinavia, Iberia and Oceania. *Land Use Policy*, *36*, 60–72. https://doi.org/10.1016/j.landusepol.2013.07.003

Brunsdon, C., Fotheringham, A. S., & Charlton, M. (1999). SOME NOTES ON PARAMETRIC SIGNIFICANCE TESTS FOR. *Journal of Regional Science*, *39*(3), 497–524.

Bureau of Chugoku and Shikoku Agricultural Administration, M. (2016). *Agricultural structure of the Chugoku and Shikoku region from the 2015 census of agriculture and forestry*.

Chiou, Y.-C., Jou, R.-C., & Yang, C.-H. (2015). Factors affecting public transportation usage rate: Geographically weighted regression. *Transportation Research Part A: Policy and Practice*, *78*, 161–177. https://doi.org/10.1016/j.tra.2015.05.016

Clement, F., Orange, D., Williams, M., Mulley, C., & Epprecht, M. (2009). Drivers of afforestation in Northern Vietnam: Assessing local variations using geographically weighted regression. *Applied Geography*, *29*, 561–576. https://doi.org/10.1016/j.apgeog.2009.01.003

Corbelle-Rico, E., Crecente-Maseda, R., & Santé-Riveira, I. (2012). Multi-scale assessment and spatial modelling of agricultural land abandonment in a European peripheral region: Galicia (Spain), 1956-2004. *Land Use Policy*, *29*(3), 493–501. https://doi.org/10.1016/j.landusepol.2011.08.008

Corbelle-Rico, Eduardo, & Crecente-Maseda, R. (2014). Evaluating IRENA indicator "Risk of Farmland Abandonment" on a low spatial scale level: The case of Galicia (Spain). *Land Use Policy*, *38*, 9–15. https://doi.org/10.1016/j.landusepol.2013.10.013

Czyzewski, B., & Matuszczak, A. (2016). A new land rent theory for sustainable agriculture. *Land Use Policy*, *55*, 222–229. https://doi.org/10.1016/j.landusepol.2016.04.002

Deininger, K., Savastano, S., & Carletto, C. (2012). Land Fragmentation, Cropland Abandonment, and Land Market Operation in Albania. *World Development*, *40*(10), 2108–2122. https://doi.org/10.1016/j.worlddev.2012.05.010

Deng, X., Xu, D., Zeng, M., & Qi, Y. (2019). Does Internet use help reduce rural cropland abandonment? Evidence from China. *Land Use Policy*, *89*(February), 104243. https://doi.org/10.1016/j.landusepol.2019.104243

Díaz, G. I., Nahuelhual, L., Echeverría, C., & Marín, S. (2011). Drivers of land abandonment in Southern Chile and implications for landscape planning. *Landscape and Urban Planning*, *99*, 207–217. https://doi.org/10.1016/j.landurbplan.2010.11.005

Estel, S., Kuemmerle, T., Alcántara, C., Levers, C., Prishchepov, A., & Hostert, P. (2015). Mapping farmland abandonment and recultivation across Europe using MODIS NDVI time series. *Remote Sensing of Environment*, *163*, 312–325. https://doi.org/10.1016/j.rse.2015.03.028

Etter, A., McAlpine, C., Wilson, K., Phinn, S., & Possingham, H. (2006). Regional patterns of agricultural land use and deforestation in Colombia. *Agriculture, Ecosystems and Environment*, *114*(2–4), 369–386. https://doi.org/10.1016/j.agee.2005.11.013

European, U., & Affairs, N. M. of E. (2004). *Land abandonment, biodiversity and the CAP (Common Agricultural Policy). Land abandonment and biodiversity, in relation to the 1st and 2nd pillars of the eu's common agricultural policy*.

FAO. (2006). *The role of agriculture and rural development in revitalizing abandoned/depopulated areas. The 34th Session of the European Commission on*

Agriculture (Riga 7 June 2006).

Foucher, A., Evrard, O., Chabert, C., Cerdan, O., Lefèvre, I., Vandromme, R., & Salvador-Blanes, S. (2019). Erosional response to land abandonment in rural areas of Western Europe during the Anthropocene: A case study in the Massif-Central, France. *Agriculture, Ecosystems and Environment*, *284*(March), 106582. https://doi.org/10.1016/j.agee.2019.106582

Fukamachi, K. (2017). Sustainability of terraced paddy fields in traditional satoyama landscapes of Japan. *Journal of Environmental Management*, *202*, 543–549. https://doi.org/10.1016/j.jenvman.2016.11.061

García-Ruiz, J. M., & Lana-Renault, N. (2011). Hydrological and erosive consequences of farmland abandonment in Europe, with special reference to the Mediterranean region – A review. *Agriculture, Ecosystems & Environment*, *140*(3–4), 317–338. https://doi.org/10.1016/j.agee.2011.01.003

Gellrich, M., Baur, P., Koch, B., & Zimmermann, N. E. (2007). Agricultural land abandonment and natural forest re-growth in the Swiss mountains: A spatially explicit economic analysis. *Agriculture, Ecosystems and Environment*, *118*, 93–108. https://doi.org/10.1016/j.agee.2006.05.001

Gellrich, M., & Zimmermann, N. E. (2007). Investigating the regional-scale pattern of agricultural land abandonment in the Swiss mountains: A spatial statistical modelling approach. *Landscape and Urban Planning*, *79*, 65–76. https://doi.org/10.1016/j.landurbplan.2006.03.004

George-Mulgan, A. (2004). *Japan's Interventionist State: The Role of the MAFF*. Taylor & Francis. Retrieved from https://books.google.co.jp/books?id=xCf8_GZQWx4C

Gibon, A., Sheeren, D., Monteil, C., Ladet, S., & Balent, G. (2010). Modelling and simulating change in reforesting mountain landscapes using a social-ecological framework. *Landscape Ecology*, *25*, 267–285. https://doi.org/10.1007/s10980-009-9438-5

Gorman, R. (2018). Human-livestock relationships and community supported agriculture (CSA) in the UK. *Journal of Rural Studies*, *61*(July 2017), 175–183. https://doi.org/10.1016/j.jrurstud.2018.04.013

Grədinaru, S. R., Iojə, C. I., Onose, D. A., Gavrilidis, A. A., Pətru-Stupariu, I., Kienast, F., & Hersperger, A. M. (2015). Land abandonment as a precursor of built-up development at the sprawling periphery of former socialist cities. *Ecological Indicators*, *57*, 305–313. https://doi.org/10.1016/j.ecolind.2015.05.009

Haddaway, N. R., Styles, D., & Pullin, A. S. (2014). Environmental impacts of farm land abandonment in high altitude/mountain regions: a systematic map of the evidence. *Environmental Evidence*, *2*. https://doi.org/10.1186/2047-2382-2-18

Heller, P. S. (2016). The challenge of an aged and shrinking population: Lessons to be drawn from Japan's experience. *Journal of the Economics of Ageing*, *8*, 85–93. https://doi.org/10.1016/j.jeoa.2016.02.001

Hisano, S., Akitsu, M., & McGreevy, S. R. (2018). Revitalising rurality under the neoliberal transformation of agriculture: Experiences of re-agrarianisation in Japan. *Journal of Rural Studies*, (January), 1–12. https://doi.org/10.1016/j.jrurstud.2018.01.013

Hori, C. (2012). Mizuho Economic Outlook & Analysis Farm Land Policy and Agriculture Recovery after the Great East Japan Earthquake.

Hoshino, S. (2001). Multilevel modeling on farmland distribution in Japan. *Land Use Policy*, *18*(1), 75–90. https://doi.org/10.1016/S0264-8377(00)00048-X

Iba, H. (2010). A Study on the Negative Effect of Subsidies on Farm Businesses (in Japanese). *Journal of Rural Problems*, *46*(1), 51–56. https://doi.org/10.7310/arfe.46.51

Ichikawa, Y. (2011). Form of a Large Cooperative Farming Group in a Hilly and Mountainous Region: Case Study of Iijima, Nagano Prefecture, Japan (in Japanese). *Geographical Review of Japan*, (July), 324–344.

Imai, S., Shikata, Y., & Zou, J. (2008). 広島県における集落営農法人の経営と構成農家の発展. *Journal of Rural Problems*, *44*(1), 79–84.

Inaba, H. (2006). Measurement Analysis of the Cultivated Acreage and Abandoned Cultivated Lands (in Japanese). *Economic Journal of Chiba University*, *20*(2), 153–174. https://doi.org/10.1177/0047117806063846

Ito, J., Feuer, H. N., Kitano, S., & Asahi, H. (2019). Assessing the effectiveness of Japan's community-based direct payment scheme for hilly and mountainous areas. *Ecological Economics*, *160*(November 2018), 62–75. https://doi.org/10.1016/j.ecolecon.2019.01.036

Ito, J., Nishikori, M., Toyoshi, M., & Feuer, H. N. (2016). The contribution of land exchange institutions and markets in countering farmland abandonment in Japan. *Land Use Policy*, *57*, 582–593. https://doi.org/10.1016/j.landusepol.2016.06.020

Janus, J., & Bozek, P. (2019). Land abandonment in Poland after the collapse of socialism: Over a quarter of a century of increasing tree cover on agricultural land. *Ecological Engineering*, *138*(July), 106–117. https://doi.org/10.1016/j.ecoleng.2019.06.017

Jentzsch, H. (2017). Abandoned land , corporate farming , and farmland banks : a local perspective on the process of deregulating and redistributing farmland in Japan. *Contemporary Japan*, *29*(1), 31–46. https://doi.org/10.1080/18692729.2017.1256977

JFIR. (2009). *Japan ' s Strategy for its Agriculture in the Globalized World*. Retrieved from http://www.jfir.or.jp/e/pr/pdf/31.pdf

Johnston, B. B. F., & Mellor, J. W. (1961). The Role of Agriculture in Economic Development Author. *American Economic Association*, *51*(4), 566–593.

Juraj, L., Bezak, P., Spulerova, J., Lieskovský, T., Koleda, P., Dobrovodsk, M., & Gimmi, U. (2015). The abandonment of traditional agricultural landscape in Slovakia -Analysis of extent and driving forces. *Journal of Rural Studies*, *37*, 75–84. https://doi.org/10.1016/j.jrurstud.2014.12.007

Kamp, J., Reinhard, A., Frenzel, M., Kämpfer, S., Trappe, J., & Hölzel, N. (2018). Farmland bird responses to land abandonment in Western Siberia. *Agriculture, Ecosystems and Environment*, *268*(September), 61–69. https://doi.org/10.1016/j.agee.2018.09.009

Kanianska, R., Kizeková, M., Nováček, J., & Zeman, M. (2014). Land-use and land-cover changes in rural areas during different political systems: A case study of Slovakia from 1782 to 2006. *Land Use Policy*, *36*, 554–566. https://doi.org/10.1016/j.landusepol.2013.09.018

Kanzaka, S. (2009). *Discovering Japan : a new regional geography*. Teikoku-Shoin. Retrieved from http://ci.nii.ac.jp/ncid/BA89788007.bib

Kawashima, S. (2010). Spatial Regression Analysis on Abandoned Farm Land using Agricultural Census and its Map Data (in Japanese). *Tohoku Journal of Rural Economics*, *28*, 23–29. https://doi.org/0.11617/jrset.28.2_23

Kawashima, S., & Kano, S. (2016). Econometric Analysis ofFarming Land Abandonment in the Tohoku Region U sing Community Level Data (in Japanese). *Journal of Rural Economics*, *88*(3), 287–292. Retrieved from http://www.ghbook.ir/index.php?name=&option=com_dbook&task=readonline&book_id=13650&page=73&chkhashk=ED9C9491B4&Itemid=218&lang=fa&tmpl=component

Keenleyside, C., Tucker, G., Key, T., Lee, H., & Mcconville, A. (2010). *Farmland Abandonment in the EU: an Assessment of Trends and Prospects*.

Kemp, F. (2003). Applied multiple regression/correlation analysis for the behavioral sciences. *Journal of the Royal Statistical Society: Series D (The Statistician)*, *52*(4), 691.

Knickel, K. (1990). Agricultural Structural Change : Impact on the Rural Environment. *Journal of Rural Studies*, *6*(4), 383–393.

Kobari, M. (2018). *Changes in Japan's rice policies: looking back on 15 years since the Principle and Outline of Rice Policy Reform in 2002*. Retrieved from https://www.nochuri.co.jp/

Kolecka, N., Kozak, J., Kaim, D., Dobosz, M., Ostafin, K., Ostapowicz, K., … Price, B. (2017). Understanding farmland abandonment in the Polish Carpathians. *Applied Geography*, *88*, 62–72. https://doi.org/10.1016/j.apgeog.2017.09.002

Koyama, N. (2004). Utilization of Abandoned Cultivated Lands for Grazing (in Japanese). *Bulletin of the National Agricultural Research Center for Western Region*. Retrieved from http://ci.nii.ac.jp/naid/40006277417

Kuemmerle, T., Hostert, P., Radeloff, V. C., van der Linden, S., Perzanowski, K., & Kruhlov, I. (2008). Cross-border comparison of post-socialist farmland abandonment in the Carpathians. *Ecosystems*, *11*(4), 614–628. https://doi.org/10.1007/s10021-008-9146-z

Lane, S. J., Azuma, A., & Higuchi, H. (1998). Wildfowl damage to agriculture in Japan. *Agriculture, Ecosystems and Environment*, *70*(1), 69–77. https://doi.org/10.1016/S0167-8809(98)00114-5

Larsson, S., & Nilsson, C. (2005). A remote sensing methodology to assess the costs of preparing abandoned farmland for energy crop cultivation in northern Sweden. *Biomass and Bioenergy*, *28*, 1–6. https://doi.org/10.1016/j.biombioe.2004.05.003

Lasanta, T., Arnáez, J., Pascual, N., Ruiz-Flaño, P., Errea, M. P., & Lana-Renault, N. (2015). Space-time process and drivers of land abandonment in Europe. *Catena*. https://doi.org/10.1016/j.catena.2016.02.024

Lasanta, Teodoro, Nadal-Romero, E., & Arnáez, J. (2015). Managing abandoned farmland to control the impact of re-vegetation on the environment. The state of the art in Europe. *Environmental Science & Policy*, *52*, 99–109. https://doi.org/10.1016/j.envsci.2015.05.012

Le, Q. B. (2005). Multi-agent system for simulation of land-use and land cover change: a theoretical framework and its first implementation for an upland watershed in the Central Coast of Vietnam, *29*(0), 0–9.

Levers, C., Schneider, M., Prishchepov, A. V., Estel, S., & Kuemmerle, T. (2018). Spatial variation in determinants of agricultural land abandonment in Europe. *Science of the Total Environment*, *644*, 95–111. https://doi.org/10.1016/j.scitotenv.2018.06.326

Li, S., & Li, X. (2016). Progress and prospect on farmland abandonment (in Chinese). *Dili Xuebao/Acta Geographica Sinica*, *71*(3), 370–389.

https://doi.org/10.11821/dlxb201603002

Li, S., & Li, X. (2017). Global understanding of farmland abandonment : A review and prospects. *Journal of Geographical Sciences*, *27*, 1123–1150. https://doi.org/10.1007/s11442-017-1426-0

Lieskovský, J., Bezák, P., Špulerová, J., Lieskovský, T., Koleda, P., Dobrovodská, M., … Gimmi, U. (2015). The abandonment of traditional agricultural landscape in Slovakia - Analysis of extent and driving forces. *Journal of Rural Studies*, *37*, 75–84. https://doi.org/10.1016/j.jrurstud.2014.12.007

Liu, W., Yang, X., Zhong, S., Sissoko, F., & Wei, C. (2018). Can community-based concentration revitalise the upland villages? A case comparison of two villages in Chongqing, Southwestern China. *Habitat International*, *77*, 153–166. https://doi.org/10.1016/j.habitatint.2017.11.005

Liu, Y., Luo, T., Liu, Z., Kong, X., Li, J., & Tan, R. (2015). A comparative analysis of urban and rural construction land use change and driving forces: Implications for urban–rural coordination development in Wuhan, Central China. *Habitat International*, *47*, 113–125. https://doi.org/10.1016/j.habitatint.2015.01.012

Liu, Z., Müller, M., Rommel, J., & Feng, S. (2016). Community-based agricultural land consolidation and local elites: Survey evidence from China. *Journal of Rural Studies*, *47*, 449–458. https://doi.org/10.1016/j.jrurstud.2016.06.021

Londoño, A. C., Williams, P. R., & Hart, M. L. (2017). A change in landscape: Lessons learned from abandonment of ancient Wari agricultural terraces in Southern Peru. *Journal of Environmental Management*, *202*, 532–542. https://doi.org/10.1016/j.jenvman.2017.01.012

Löw, F., Fliemann, E., Abdullaev, I., Conrad, C., & Lamers, J. P. A. (2015). Mapping abandoned agricultural land in Kyzyl-Orda, Kazakhstan using satellite remote sensing. *Applied Geography*, *62*, 377–390. https://doi.org/10.1016/j.apgeog.2015.05.009

Löw, F., Prishchepov, A. V., Waldner, F., Dubovyk, O., Akramkhanov, A., Biradar, C., & Lamers, J. P. A. (2018). Mapping Cropland abandonment in the Aral Sea Basin with MODIS time series. *Remote Sensing*, *10*(2). https://doi.org/10.3390/rs10020159

Lutz, J., Smetschka, B., & Grima, N. (2017). Farmer cooperation as a means for creating local food systems-Potentials and challenges. *Sustainability (Switzerland)*, *9*(6). https://doi.org/10.3390/su9060925

M., J., T., R., G., N., S., T., M., M., & R., S. (2019). Is aquaculture abandonment a threat to sustainable coastal resource use? – A case study of Andhra Pradesh, India, with options for reuse. *Land Use Policy*, *86*(July 2018), 54–66. https://doi.org/10.1016/j.landusepol.2019.04.034

MacDonald, D., Crabtree, J. ., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., … Gibon, A. (2000). Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response. *Journal of Environmental Management*, *59*, 47–69. https://doi.org/10.1006/jema.1999.0335

MacIas, T. (2008). Working toward a just, equitable, and local food system: The social impact of community-based agriculture. *Social Science Quarterly*, *89*(5), 1086–1101. https://doi.org/10.1111/j.1540-6237.2008.00566.x

MAFF. (2015). *Summary of Census of Agriculture and Forestry*. Retrieved from http://www.maff.go.jp/e/data/stat/90th/index.html

MAFF. (2018). *Summary of the Annual Report on Food, Agriculture and Rural Areas in Japan*. Retrieved from http://www.maff.go.jp/e/data/publish/attach/pdf/index-93.pdf

Mallinis, G., Koutsias, N., & Arianoutsou, M. (2014). Monitoring land use/land cover transformations from 1945 to 2007 in two peri-urban mountainous areas of Athens metropolitan area, Greece. *Science of the Total Environment*, *490*, 262–278. https://doi.org/10.1016/j.scitotenv.2014.04.129

Mather, A. S. (1992). The Forest Transition. *Area*, *24*(4), 367–379. Retrieved from http://www.jstor.org/stable/20003181

Mather, A. S., & Needle, C. L. (1998). The forest transition: A theoretical basis. *Area*, *30*(2), 117–124. https://doi.org/10.1111/j.1475-4762.1998.tb00055.x

Matin, S., Sullivan, C. A., Ó hUallacháin, D., Meredith, D., Moran, J., Finn, J. A., & Green, S. (2016). Predicted distribution of High Nature Value farmland in the Republic of Ireland. *Journal of Maps*, *12*(February 2019), 373–376. https://doi.org/10.1080/17445647.2016.1223761

Matsuno, Y., Nakamura, K., Masumoto, T., Matsui, H., Kato, T., & Sato, Y. (2006). Prospects for multifunctionality of paddy rice cultivation in Japan and other countries in monsoon Asia. *Paddy and Water Environment*, *4*, 189–197. https://doi.org/10.1007/s10333-006-0048-4

McDonald, M. G. (1997). Agricultural landholding in Japan: Fifty years after land reform. *Geoforum*, *28*(1), 55–78. https://doi.org/10.1016/S0016-7185(97)85527-3

Miki Kataoka. (2018). The Management Strategies of Projects for Creating Social Values in the Rural and Farm Sectors (in Japanese). *Japanese Journal of Farm Management*, *56*(1), 34–48. https://doi.org/https://doi.org/10.11300/fmsj.56.1_34

Ministry of Land, Infrastructure, T. and T., & Land, C. (2018). *Trends Concerning Land in FY2017 Basic Measures in Relation to Land in FY2018 Abstract June 2018 Ministry of Land , Infrastructure , Transport and Tourism*.

Morimoto, T. (1991). The increase of fallow and abandoned cultivated land with the development of intensive agriculture in Hasaki Machi, Ibaraki Prefecture (in Japanese). *Geographical Review of Japan*, *64*, 613–636. Retrieved from https://www.jstage.jst.go.jp/browse/grj1984a/64/9/_contents/-char/ja/

Morimoto, T. (1993). Idle and abandoned farmland in Kashiwai-cho 4-chome, Ichikawa City, Chiba prefecture (in Japanese). *Geographical Review of Japan*, *66*, 81–87. https://doi.org/10.1007/s13398-014-0173-7.2

Mottet, A., Ladet, S., Coqué, N., & Gibon, A. (2006). Agricultural land-use change and its drivers in mountain landscapes: A case study in the Pyrenees. *Agriculture, Ecosystems & Environment*, *114*, 296–310. https://doi.org/10.1016/j.agee.2005.11.017

Müller, D., Leitão, P. J., & Sikor, T. (2013). Comparing the determinants of cropland abandonment in Albania and Romania using boosted regression trees. *Agricultural Systems*, *117*, 66–77. https://doi.org/10.1016/j.agsy.2012.12.010

Munroe, D. K., van Berkel, D. B., Verburg, P. H., & Olson, J. L. (2013). Alternative trajectories of land abandonment: Causes, consequences and research challenges. *Current Opinion in Environmental Sustainability*. https://doi.org/10.1016/j.cosust.2013.06.010

Nakae, T., & Morita, H. (2013). Evaluation of Social Factors and Geographic Factors that Affect the Distribution of Cultivation Abandonment Land (in Japanese). *JOURNAL OF RURAL PLANNING ASSOCIATION*, (2012).

Nakano, K. (2014). The "Sixth Industrialization" for Japanese Agricultural Development. *The Ritsumeikan Economic Review*.

Nihei, T. (2006). Regional Division of J apanese Agriculture in Terms of Comprehensive Indices of Farm Management: Development of a Method by Means of Multivariate Analyses and GIS (in Japanese). *Studies in Human Geography*, *30*, 69–98.

Nkonya, E., Braun, J. von, & Mirzabaev, A. (2016). *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*. *Springer Open*. https://doi.org/10.1021/om200683q

Novara, A., Gristina, L., Sala, G., Galati, A., Crescimanno, M., Cerdà, A., … La Mantia, T.

(2017). Agricultural land abandonment in Mediterranean environment provides ecosystem services via soil carbon sequestration. *Science of the Total Environment*, *576*, 420–429. https://doi.org/10.1016/j.scitotenv.2016.10.123

O'Rourke, E. (2019). Drivers of land abandonment in the Irish uplands: A case study. *European Countryside*, *11*(2), 211–228. https://doi.org/10.2478/euco-2019-0011

OECD. (2009). *Evaluation of Agricultural Policy Reforms in Japan*. *Evaluation*. https://doi.org/10.1787/9789264061545-en

Okahashi, H. (1986). Rural Deprivation in Mountainous Areas of Japan: a Preliminary Assessment (in Japanese). *Human Geography*, *38*(5), 75–93. https://doi.org/http://iss.ndl.go.jp/books/R100000002-I000000012385-00

Okahashi, H. (1996). Development of Mountain Village Studies in Postwar Japan: Depopulation, Peripheralization and Village Renaissance (in Japanese). *Geographical Review of Japan*, *69*, 60–69. https://doi.org/10.4157/grj1984b.69.60

Okahashi, H. (1997). *周辺地域の存立構造: 現代山村の形成と展開 (in Japanese)*. 大明堂. Retrieved from https://books.google.co.jp/books?id=RIyuAAAACAAJ

Okahashi, H. (2004). Mountain village in the 21st century in Japan: Exploring possibilities and Problems in the Future (in Japanese). *Journal of Geography*, *113*(2), 235–255.

Oldekop, J. A., Sims, K. R. E., Whittingham, M. J., & Agrawal, A. (2018). An upside to globalization: International outmigration drives reforestation in Nepal. *Global Environmental Change*, *52*(May), 66–74. https://doi.org/10.1016/j.gloenvcha.2018.06.004

Oliveira, S., Pereira, J. M. C., San-Miguel-Ayanz, J., & Lourenço, L. (2014). Exploring the spatial patterns of fire density in Southern Europe using Geographically Weighted Regression. *Applied Geography*, *51*, 143–157. https://doi.org/10.1016/j.apgeog.2014.04.002

Opitz, I., Zoll, F., Zasada, I., Doernberg, A., Siebert, R., & Piorr, A. (2019). Consumer-producer interactions in community-supported agriculture and their relevance for economic stability of the farm – An empirical study using an Analytic Hierarchy Process. *Journal of Rural Studies*, *68*(March), 22–32. https://doi.org/10.1016/j.jrurstud.2019.03.011

Ord, J. K., & Getis, A. (1995). Local Spatial Autocorrelation Statistics: Distributional Issues and an Application. *Geographical Analysis*, *27*, 286–306. https://doi.org/10.1111/j.1538-4632.1995.tb00912.x

Osawa, T., Kohyama, K., & Mitsuhashi, H. (2016). Multiple factors drive regional agricultural abandonment. *Science of the Total Environment*, *542*, 478–483. https://doi.org/10.1016/j.scitotenv.2015.10.067

P. Pointereau, Coulon, F., P.Girard, M.Lambotte, Stuczynski, T., Ortega, V. S., & Rio, A. Del. (2008). *Analysis of the Driving Forces behind Farmland Abandonment and the Extent and Location of Agricultural Areas that are Actually Abandoned or are in Risk to be Abandoned*. *European Communities,*. Ispra, Italy,. Retrieved from http://publications.jrc.ec.europa.eu/repository/handle/JRC46185

Parcerisas, L., Marull, J., Pino, J., Tello, E., Coll, F., & Basnou, C. (2012). Land use changes, landscape ecology and their socioeconomic driving forces in the Spanish Mediterranean coast (El Maresme County, 1850-2005). *Environmental Science and Policy*, *23*, 120–132. https://doi.org/10.1016/j.envsci.2012.08.002

Patil, S., & Kokate, K. (2017). Identifying factors governing attitude of rural women towards Self-Help Groups using principal component analysis. *Journal of Rural Studies*, *55*, 157–167. https://doi.org/10.1016/j.jrurstud.2017.08.003

Pazúr, R., Lieskovský, J., Feranec, J., & Oťaheľ, J. (2014). Spatial determinants of abandonment of large-scale arable lands and managed grasslands in Slovakia during the periods of post-socialist transition and European Union accession. *Applied Geography*, *54*, 118–128. https://doi.org/10.1016/j.apgeog.2014.07.014

Peredo, A. M., & Christman, J. J. (2006). Towards a theory of community-based enterprise. *Academy of Management Review*, *31*(2), 309–328. https://doi.org/10.5465/AMR.2006.20208683

Pineda Jaimes, N. B., Bosque Sendra, J., Gómez Delgado, M., & Franco Plata, R. (2010). Exploring the driving forces behind deforestation in the state of Mexico (Mexico) using geographically weighted regression. *Applied Geography*, *30*, 576–591. https://doi.org/10.1016/j.apgeog.2010.05.004

Plieninger, T., Draux, H., Fagerholm, N., Bieling, C., Bürgi, M., Kizos, T., … Verburg, P. H. (2016). The driving forces of landscape change in Europe: A systematic review of the evidence. *Land Use Policy*, *57*, 204–214. https://doi.org/10.1016/j.landusepol.2016.04.040

Prishchepov, A. A., Müller, D., Dubinin, M., Baumann, M., & Radeloff, V. C. (2013). Determinants of agricultural land abandonment in post-Soviet European Russia. *Land Use Policy*, *30*, 873–884. https://doi.org/10.1016/j.landusepol.2012.06.011

Prishchepov, A. V., Radeloff, V. C., Baumann, M., Kuemmerle, T., & Müller, D. (2012). Effects of institutional changes on land use: agricultural land abandonment during the transition from state-command to market-driven economies in post-Soviet Eastern Europe. *Environmental Research Letters*, *7*, 024021. https://doi.org/10.1088/1748-9326/7/2/024021

Queiroz, C., Beilin, R., Folke, C., & Lindborg, R. (2014). Farmland abandonment: Threat or opportunity for biodiversity conservation? A global review. *Frontiers in Ecology and the Environment*, *12*(5), 288–296. https://doi.org/10.1890/120348

Ramankutty, N., Heller, E., & Rhemtulla, J. (2010). Prevailing myths about agricultural abandonment and forest regrowth in the United States. *Annals of the Association of American Geographers*, *100*(3), 502–512. https://doi.org/10.1080/00045601003788876

Rautiainen, A., Virtanen, T., & Kauppi, P. E. (2016). Land cover change on the Isthmus of Karelia 1939-2005: Agricultural abandonment and natural succession. *Environmental Science and Policy*, *55*, 127–134. https://doi.org/10.1016/j.envsci.2015.09.011

Renwick, A., Jansson, T., Verburg, P. H., Revoredo-Giha, C., Britz, W., Gocht, A., & McCracken, D. (2013). Policy reform and agricultural land abandonment in the EU. *Land Use Policy*, *30*(1), 446–457. https://doi.org/10.1016/j.landusepol.2012.04.005

Rey Benayas, J. (2007). Abandonment of agricultural land: an overview of drivers and consequences. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources*, *2*(057). https://doi.org/10.1079/PAVSNNR20072057

Rudel, T. K., Coomes, O. T., Moran, E., Achard, F., Angelsen, A., Xu, J., & Lambin, E. (2005). Forest transitions: Towards a global understanding of land use change. *Global Environmental Change*, *15*(1), 23–31. https://doi.org/10.1016/j.gloenvcha.2004.11.001

Rudel, T. K., Schneider, L., & Uriarte, M. (2010). Forest transitions: An introduction. *Land Use Policy*, *27*(2), 95–97. https://doi.org/10.1016/j.landusepol.2009.09.021

Ruskule, A., Nikodemus, O., Kasparinskis, R., Bell, S., & Urtane, I. (2013). The perception of abandoned farmland by local people and experts: Landscape value and perspectives on future land use. *Landscape and Urban Planning*, *115*, 49–61. https://doi.org/10.1016/j.landurbplan.2013.03.012

Ryan E. Galt. (2003). The Moral Economy Is a Double-edged Sword: Explaining Farmers' Earnings and Self-exploitation in Community-Supported Agriculture. *Economic Geography*, *89*(4), 341–365. https://doi.org/10.1111/ecge.12015

Sang, N., Dramstad, W. E., & Bryn, A. (2014). Regionality in Norwegian farmland abandonment: Inferences from production data. *Applied Geography*, *55*, 238–247.

https://doi.org/10.1016/j.apgeog.2014.09.015

Sanz, A. S. R., Fernandez, C., Mouillot, F., Ferrat, L., Istria, D., & Pasqualini, V. (2013). Long-term forest dynamics and land-use abandonment in the Mediterranean Mountains, Corsica, France. *Ecology and Society*, *18*(2). https://doi.org/10.5751/ES-05556-180238

Scherr, S. J., & McNeely, J. A. (2008). Biodiversity conservation and agricultural sustainability: Towards a new paradigm of “ecoagriculture” landscapes. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1491), 477–494. https://doi.org/10.1098/rstb.2007.2165

Schneider, M., Blanchard, G., Levers, C., & Kuemmerle, T. (2015). Spatial Variation of Drivers of Agricultural Abandonment with Spatially Boosted Models. *Procedia Environmental Sciences*, *27*, 53–57. https://doi.org/10.1016/j.proenv.2015.07.114

Shimizu, T. (2017). *Present state of Japanese agriculture and future prospect for agricultural structure : Detailed picture seen in 2015 Agricultural Census*.

Shindo, K., & Tejima, S. (2006). Livestock Production by Integrated Grazing System for Scattered Small Pastures in Eastern Japan (in Japanese). *Japanese Sooiety of Grassland Soienoe*, *52*(2), 111–113.

Shiroishi, Y., Uchiyama, K., & Suzuki, N. (2018). Society 5.0: For Human Security and Well-Being. *Computer*, *51*(7), 91–95. https://doi.org/10.1109/MC.2018.3011041

Shoji, G. (2015). Prevention Mechanism of Farmland Abandonment in a Mountain Village in Nishi-Aizu Town. *Quarterly Journal of Geography*, *66*, 284–297. https://doi.org/10.5190/tga.66.284

Shoyama, K., & Braimoh, A. K. (2011). Analyzing about sixty years of land-cover change and associated landscape fragmentation in Shiretoko Peninsula, Northern Japan. *Landscape and Urban Planning*, *101*(1), 22–29. https://doi.org/10.1016/j.landurbplan.2010.12.016

Sil, Â., Fernandes, P. M., Rodrigues, A. P., Alonso, J. M., Honrado, J. P., Perera, A., & Azevedo, J. C. (2019). Farmland abandonment decreases the fire regulation capacity and the fire protection ecosystem service in mountain landscapes. *Ecosystem Services*, *36*(December 2018), 100908. https://doi.org/10.1016/j.ecoser.2019.100908

Sluiter, R., & De Jong, S. M. (2007). Spatial patterns of Mediterranean land abandonment and related land cover transitions. *Landscape Ecology*, *22*(4), 559–576. https://doi.org/10.1007/s10980-006-9049-3

Sohel, S. I., Rana, P., Islam, A. Z. M. Z., & Akhter, S. (2011). Monitoring Land-use Changes by Remote Sensing and GIS Techniques : Case Study of Barind Tract , Bangladesh, *27*(2), 73–79.

Sroka, W., Mikolajczyk, J., Wojewodzic, T., & Kwoczynska, B. (2018). Agricultural land vs. Urbanisation in chosen Polish Metropolitan Areas: A spatial analysis based on regression trees. *Sustainability (Switzerland)*, *10*(3). https://doi.org/10.3390/su10030837

Statistics Bureau. (2018). *Statistical Handbook of Japan*. Retrieved from https://www.stat.go.jp/english/data/handbook/index.html

Statistics Bureau, M. of I. A. and C. (2016). *Statistical Handbook of Japan, 2016*. Retrieved from https://www.stat.go.jp/english/data/handbook/pdf/2016all.pdf

Su, G., Okahashi, H., & Chen, L. (2018). Spatial Pattern of Farmland Abandonment in Japan: Identification and Determinants. *Sustainability*, *10*(10), 3676. https://doi.org/10.3390/su10103676

Takahashi, D. (2015). The Agricultural Adjustment Problem of Japanese Agriculture : Technological Progress , Price Policies and Farmland Policies. *Journal of Rural Economics Back Issue*, *87*, 9–22. https://doi.org/10.11472/nokei.87.9

Takahashi, T. (1997). Analysis of Characteristics of Abandoned Farmland and Preventive Measures in Urbanized Farming Communities Studies on prevention of abandonment of cultivation in suburban area (II) (in Japanese). *Journal of Irrigation Engineering and Rural Planning*, *191*(191). Retrieved from http://doi.org/10.11408/jsidre1965.1997.615

Takeo Kubo. (2014). Issues and Methods of Training Successors at Agricultural Production Corporations (in Japanese). *Journal of Rural Problems*, 1–10.

Takeyama, E., Sasayama, S., Nonaka, Y., & Kuki, Y. (2015). Influence of Abandoned Farmland and Protection Fence on Agglomeration and Connectivity of Wild Boar Habitat around Orchard Field. *Transactions of The Japanese Society of Irrigation, Drainage and Rural Engineering*, *296*(83–2), 25–31.

Tashiro, A., Uchiyama, Y., & Kohsaka, R. (2019). Impact of Geographical Indication schemes on traditional knowledge in changing agricultural landscapes: An empirical analysis from Japan. *Journal of Rural Studies*, *68*(June 2018), 46–53. https://doi.org/10.1016/j.jrurstud.2019.03.014

Teffera, Z. L., Li, J., Debsu, T. M., & Menegesha, B. Y. (2018). Assessing land use and land cover dynamics using composites of spectral indices and principal component analysis: A case study in middle Awash subbasin, Ethiopia. *Applied Geography*, *96*(December 2017), 109–129. https://doi.org/10.1016/j.apgeog.2018.05.015

Teratoko, Y. (2009). Expansion of Abandoned Cultivated Land and Related Factors in a

Marginal Hamlet in Minamata, Kumamoto Prefecture (in Japanese). *Geographical Review of Japan Series A*, *82*(6), 588–603.

Terres, J.-M., Scacchiafichi, L. N., Wania, A., Ambar, M., Anguiano, E., Buckwell, A., … Zobena, A. (2015). Farmland abandonment in Europe: Identification of drivers and indicators, and development of a composite indicator of risk. *Land Use Policy*, *49*, 20–34. https://doi.org/10.1016/j.landusepol.2015.06.009

Thornton, A. (2009). Pastures of plenty?: Land rights and community-based agriculture in Peddie, a former homeland town in South Africa. *Applied Geography*, *29*(1), 12–20. https://doi.org/10.1016/j.apgeog.2008.06.001

Tu, J. (2011). Spatially varying relationships between land use and water quality across an urbanization gradient explored by geographically weighted regression. *Applied Geography*, *31*, 376–392. https://doi.org/10.1016/j.apgeog.2010.08.001

Uddin, M. N., Saiful Islam, A. K. M., Bala, S. K., Islam, G. M. T., Adhikary, S., Saha, D., … Akter, R. (2019). Mapping of climate vulnerability of the coastal region of Bangladesh using principal component analysis. *Applied Geography*, *102*(May 2016), 47–57. https://doi.org/10.1016/j.apgeog.2018.12.011

Uematsu, Y., Koga, T., Mitsuhashi, H., & Ushimaru, A. (2010). Abandonment and intensified use of agricultural land decrease habitats of rare herbs in semi-natural grasslands. *Agriculture, Ecosystems and Environment*, *135*(4), 304–309. https://doi.org/10.1016/j.agee.2009.10.010

Ustaoglu, E., & Collier, M. J. (2018). Farmland Abandonment in Europe: An Overview of Drivers, Consequences and Assessment of the Sustainability Implications. *Environmental Reviews*, (October), er-2018-0001. https://doi.org/10.1139/er-2018-0001

Valbuena, D., Verburg, P. H., Bregt, A. K., & Ligtenberg, A. (2010). An agent-based approach to model land-use change at a regional scale. *Landscape Ecology*, *25*(2), 185–199. https://doi.org/10.1007/s10980-009-9380-6

van der Zanden, E. H., Carvalho-Ribeiro, S. M., & Verburg, P. H. (2018). Abandonment landscapes: user attitudes, alternative futures and land management in Castro Laboreiro, Portugal. *Regional Environmental Change*, *18*(5), 1509–1520. https://doi.org/10.1007/s10113-018-1294-x

van der Zanden, E. H., Verburg, P. H., Schulp, C. J. E., & Verkerk, P. J. (2017). Trade-offs of European agricultural abandonment. *Land Use Policy*, *62*, 290–301. https://doi.org/10.1016/j.landusepol.2017.01.003

Verburg, P. H., & Overmars, K. P. (2009). Combining top-down and bottom-up dynamics in land use modeling: Exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model. *Landscape Ecology*, *24*(9), 1167–1181. https://doi.org/10.1007/s10980-009-9355-7

Viedma, O., Moity, N., & Moreno, J. M. (2015). Changes in landscape fire-hazard during the second half of the 20th century: Agriculture abandonment and the changing role of driving factors. *Agriculture, Ecosystems and Environment*, *207*, 126–140. https://doi.org/10.1016/j.agee.2015.04.011

Vinogradovs, I., Nikodemus, O., Elferts, D., & Brūmelis, G. (2018). Assessment of site-specific drivers of farmland abandonment in mosaic-type landscapes: A case study in Vidzeme, Latvia. *Agriculture, Ecosystems and Environment*, *253*(November 2017), 113–121. https://doi.org/10.1016/j.agee.2017.10.016

von Thünen, J. H., & Hall, P. (1966). *Isolated State: An English Edition of Der Isolierte Staat*. Pergamon Press. Retrieved from https://books.google.co.jp/books?id=sT5NfzN2er0C

Williams, K. J. H., & Schirmer, J. (2012). Understanding the relationship between social change and its impacts: The experience of rural land use change in south-eastern Australia. *Journal of Rural Studies*, *28*(4), 538–548. https://doi.org/10.1016/j.jrurstud.2012.05.002

Xie, H., Wang, P., & Yao, G. (2014). Exploring the dynamic mechanisms of farmland abandonment based on a spatially explicit economic model for environmental sustainability: A case study in Jiangxi Province, China. *Sustainability*, *6*, 1260–1282. https://doi.org/10.3390/su6031260

Xu, D., Deng, X., Guo, S., & Liu, S. (2019). Labor migration and farmland abandonment in rural China: Empirical results and policy implications. *Journal of Environmental Management*, *232*(November 2018), 738–750. https://doi.org/10.1016/j.jenvman.2018.11.136

Xue, Z., Zhen, L., Miah, M. G., & Shoyama, K. (2019). Impact assessment of land use functions on the sustainable regional development of representative Asian countries – A comparative study in Bangladesh, China and Japan. *Science of The Total Environment*, *694*, 133689. https://doi.org/10.1016/j.scitotenv.2019.133689

Yabiki, N. (2015). Analysis of the Abandonment of Cultivated Area and Community-based Farm Cooperatives from Statistical Data (in Japanese). *Technical Report of the National Institute for Rural Engineering*, *217*, 75–83.

Yamaguchi, T., Ngodup, S., Nose, M., & Takeda, S. (2016). Community-scale analysis of the farmland abandonment occurrence process in the mountain region of Ladakh, India. *Journal of Land Use Science*, *11*(4), 401–416. https://doi.org/10.1080/1747423X.2016.1174317

Yamashita, R., & Hoshino, S. (2018). Development of an agent-based model for estimation of agricultural land preservation in rural Japan. *Agricultural Systems*, *164*(January 2017), 264–276. https://doi.org/10.1016/j.agsy.2018.05.004

Yan, J., Yang, Z., Li, Z., Li, X., Xin, L., & Sun, L. (2016). Drivers of cropland abandonment in mountainous areas: A household decision model on farming scale in Southwest China. *Land Use Policy*, *57*, 459–469. https://doi.org/10.1016/j.landusepol.2016.06.014

Yang, J., Zhang, Z., Dawazhaxi, Wang, B., Li, Q., Yu, Q., … Ali, K. (2019). Spatial distribution patterns and intra-specific competition of pine (Pinus yunnanensis) in abandoned farmland under the Sloping Land Conservation Program. *Ecological Engineering*, *135*(May), 17–27. https://doi.org/10.1016/j.ecoleng.2019.04.026

Ye, Y., & Fang, X. (2011). Spatial pattern of land cover changes across Northeast China over the past 300 years. *Journal of Historical Geography*, *37*(4), 408–417. https://doi.org/10.1016/j.jhg.2011.08.018

Yin, H., Butsic, V., Buchner, J., Kuemmerle, T., Prishchepov, A. V., Baumann, M., … Radeloff, V. C. (2019). Agricultural abandonment and re-cultivation during and after the Chechen Wars in the northern Caucasus. *Global Environmental Change*, *55*(January), 149–159. https://doi.org/10.1016/j.gloenvcha.2019.01.005

Yokomichi, K. (2007). The development of municipal mergers in Japan. *Up-to-Date Documents on Local Autonomy in Japan*, *4*(1).

Zakkak, S., Radovic, A., Nikolov, S. C., Shumka, S., Kakalis, L., & Kati, V. (2015). Assessing the effect of agricultural land abandonment on bird communities in southern-eastern Europe. *Journal of Environmental Management*, *164*, 171–179. https://doi.org/10.1016/j.jenvman.2015.09.005

Zambon, I., Ferrara, A., Salvia, R., Mosconi, E. M., Fici, L., Turco, R., & Salvati, L. (2018). Rural districts between urbanization and land abandonment: Undermining long-term changes in mediterranean landscapes. *Sustainability (Switzerland)*, *10*(4), 1–17. https://doi.org/10.3390/su10041159

Zaragozí, B., Rabasa, A., Rodríguez-Sala, J. J., Navarro, J. T., Belda, A., & Ramón, A. (2012). Modelling farmland abandonment: A study combining GIS and data mining techniques. *Agriculture, Ecosystems & Environment*, *155*, 124–132.

https://doi.org/10.1016/j.agee.2012.03.019

Zeinalzadeh, K., & Rezaei, E. (2017). Determining spatial and temporal changes of surface water quality using principal component analysis. *Journal of Hydrology: Regional Studies*, *13*(August), 1–10. https://doi.org/10.1016/j.ejrh.2017.07.002

Zhang, Y., Li, X., & Song, W. (2014). Determinants of cropland abandonment at the parcel, household and village levels in mountain areas of China: A multi-level analysis. *Land Use Policy*, *41*, 186–192. https://doi.org/10.1016/j.landusepol.2014.05.011

Zhang, Y., Li, X., Song, W., & Zhai, L. (2016). Land abandonment under rural restructuring in China explained from a cost-benefit perspective. *Journal of Rural Studies*, *47*, 524–532. https://doi.org/10.1016/j.jrurstud.2016.06.019

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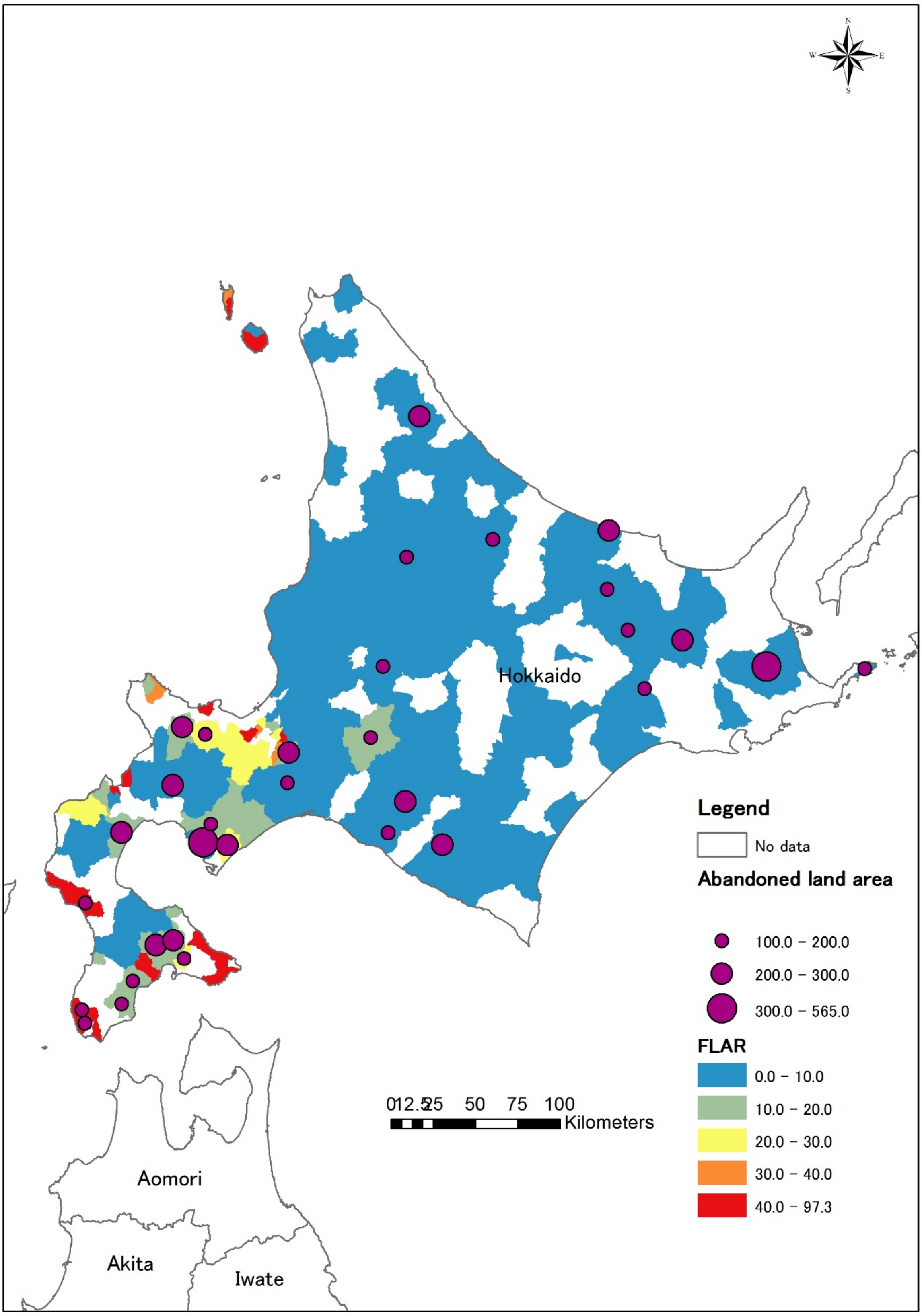
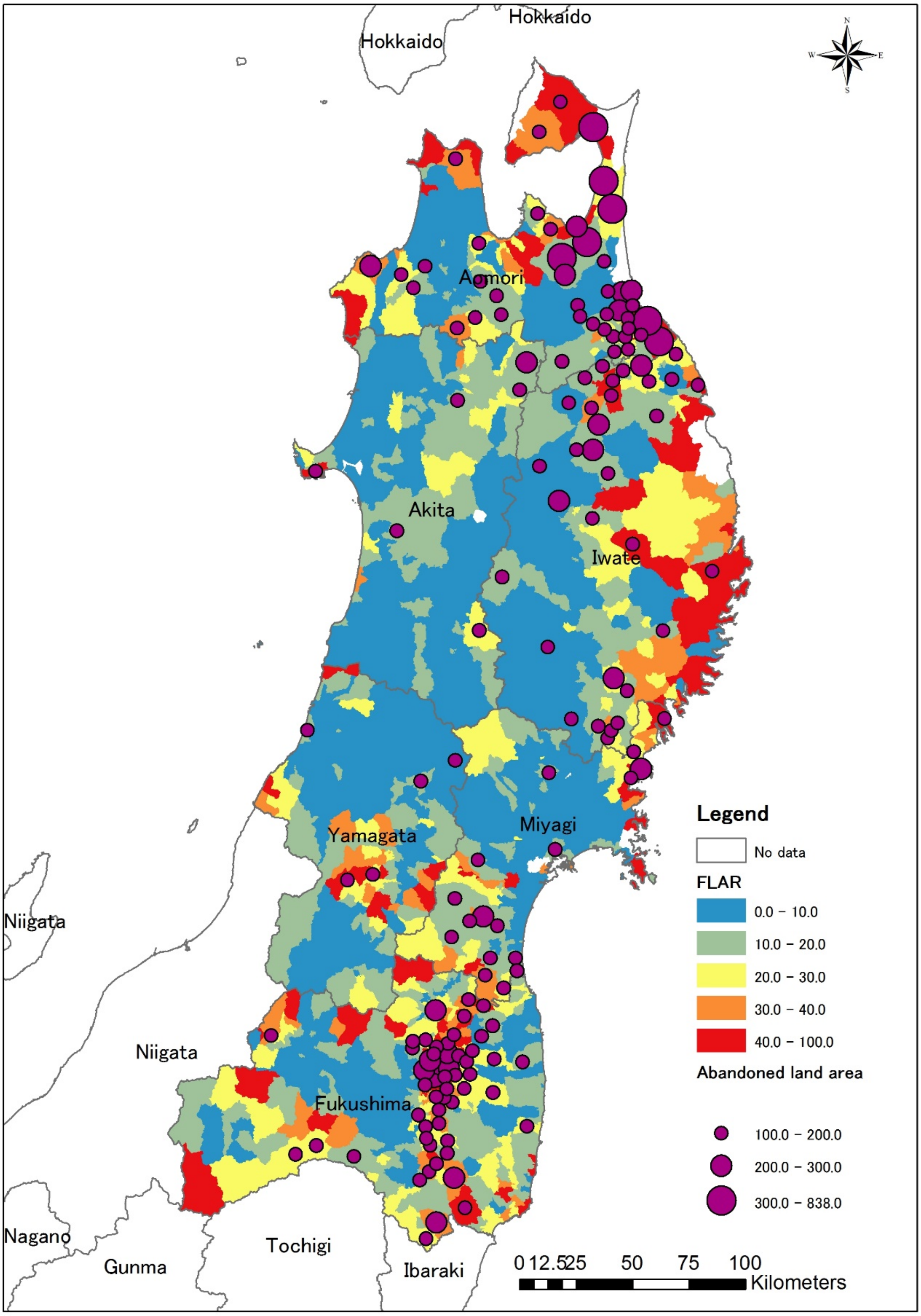
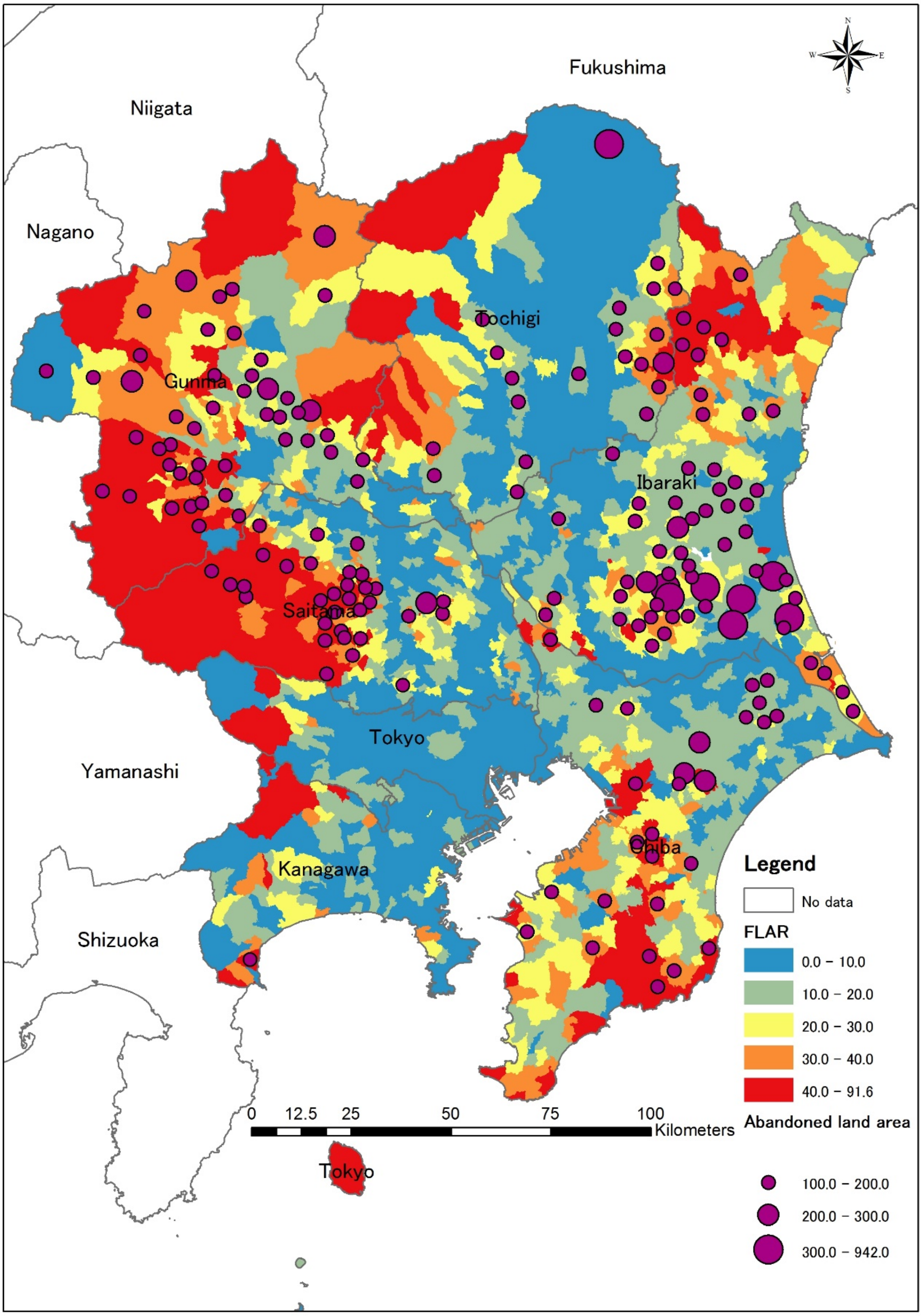
Appendix



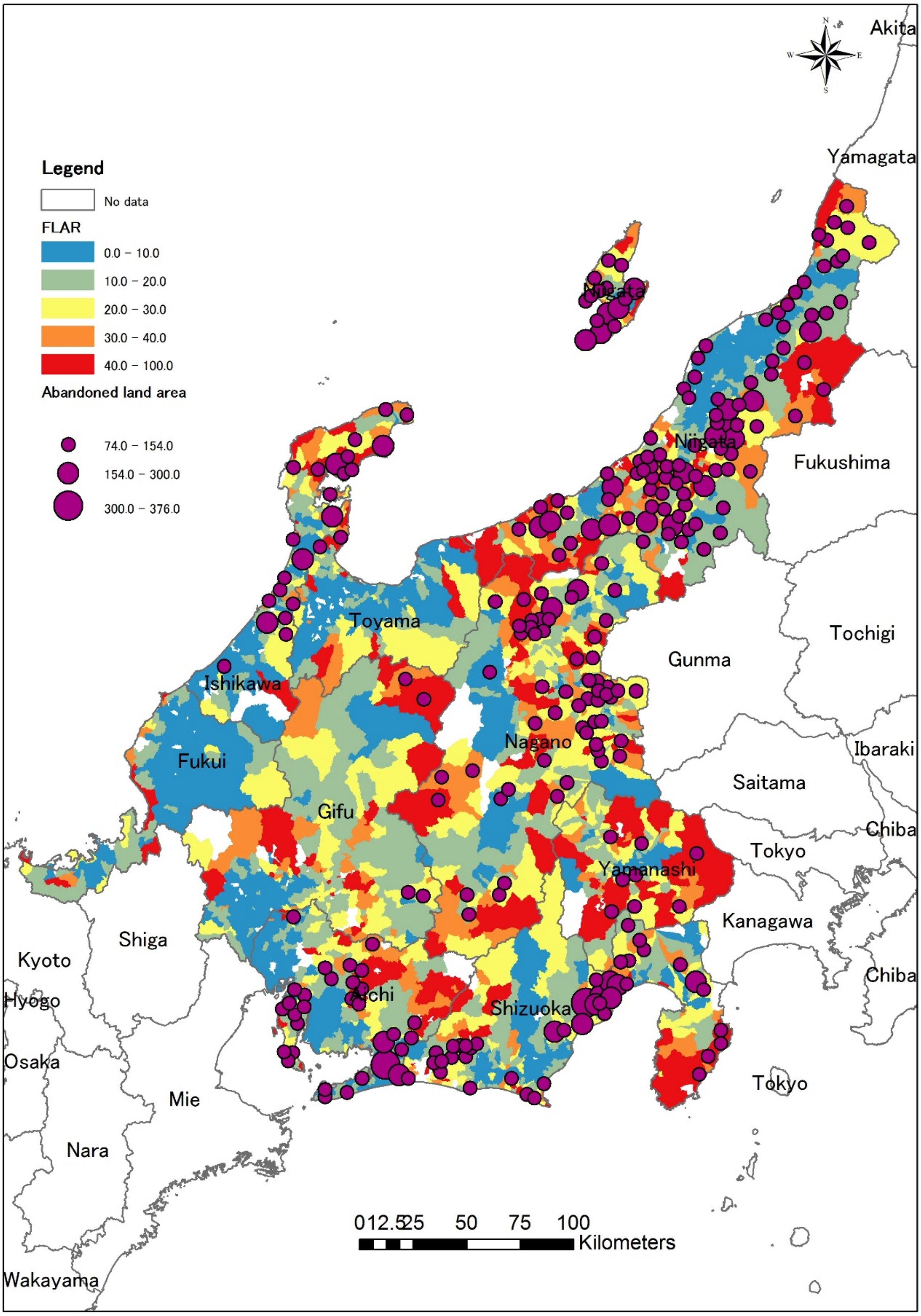
Appendix I FLAR and FLA area of Hokkaido in 2010



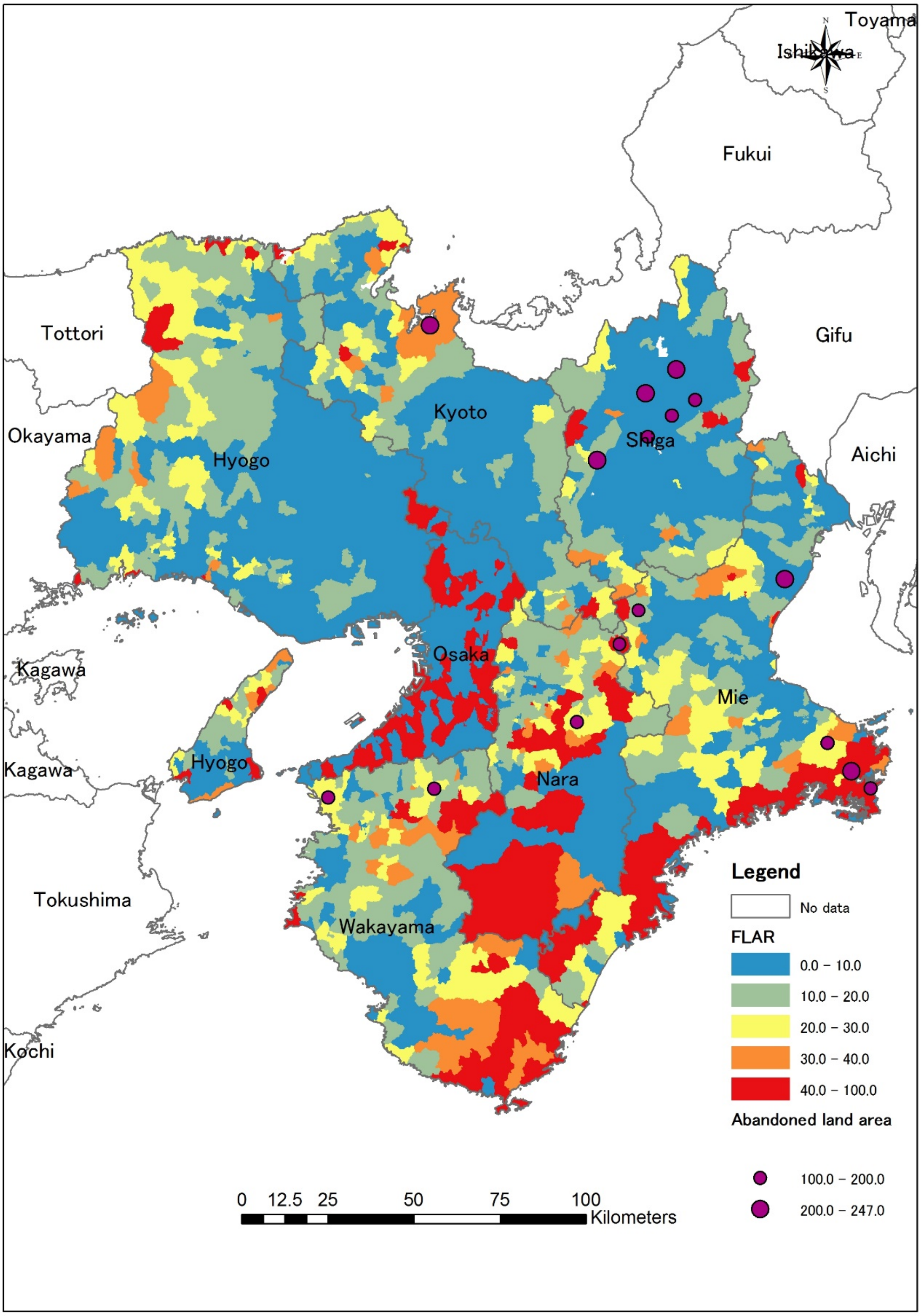
Appendix II FLAR and FLA area of Tohoku Region in 2010



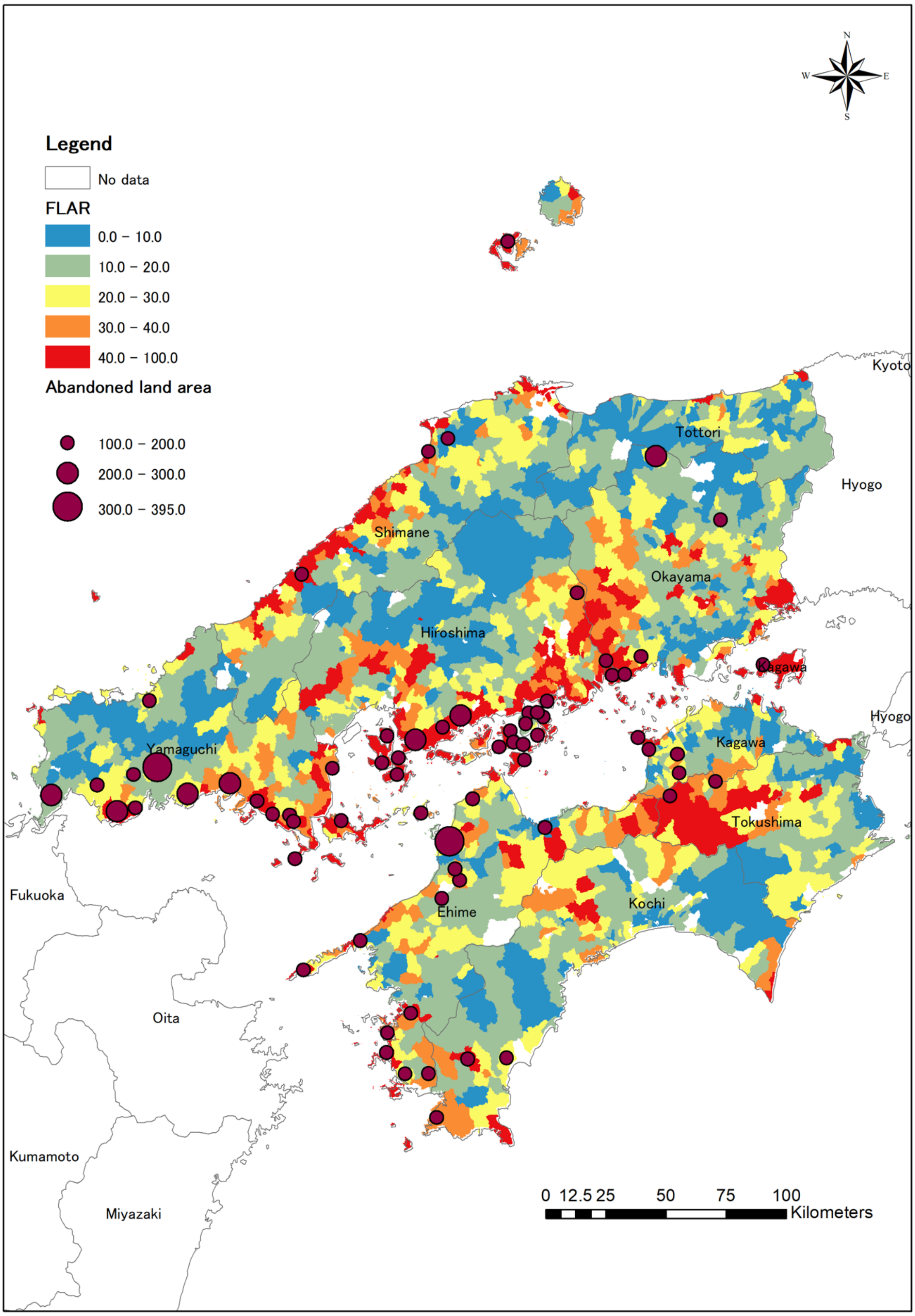
Appendix III FLAR and FLA area of Kanto Region in 2010



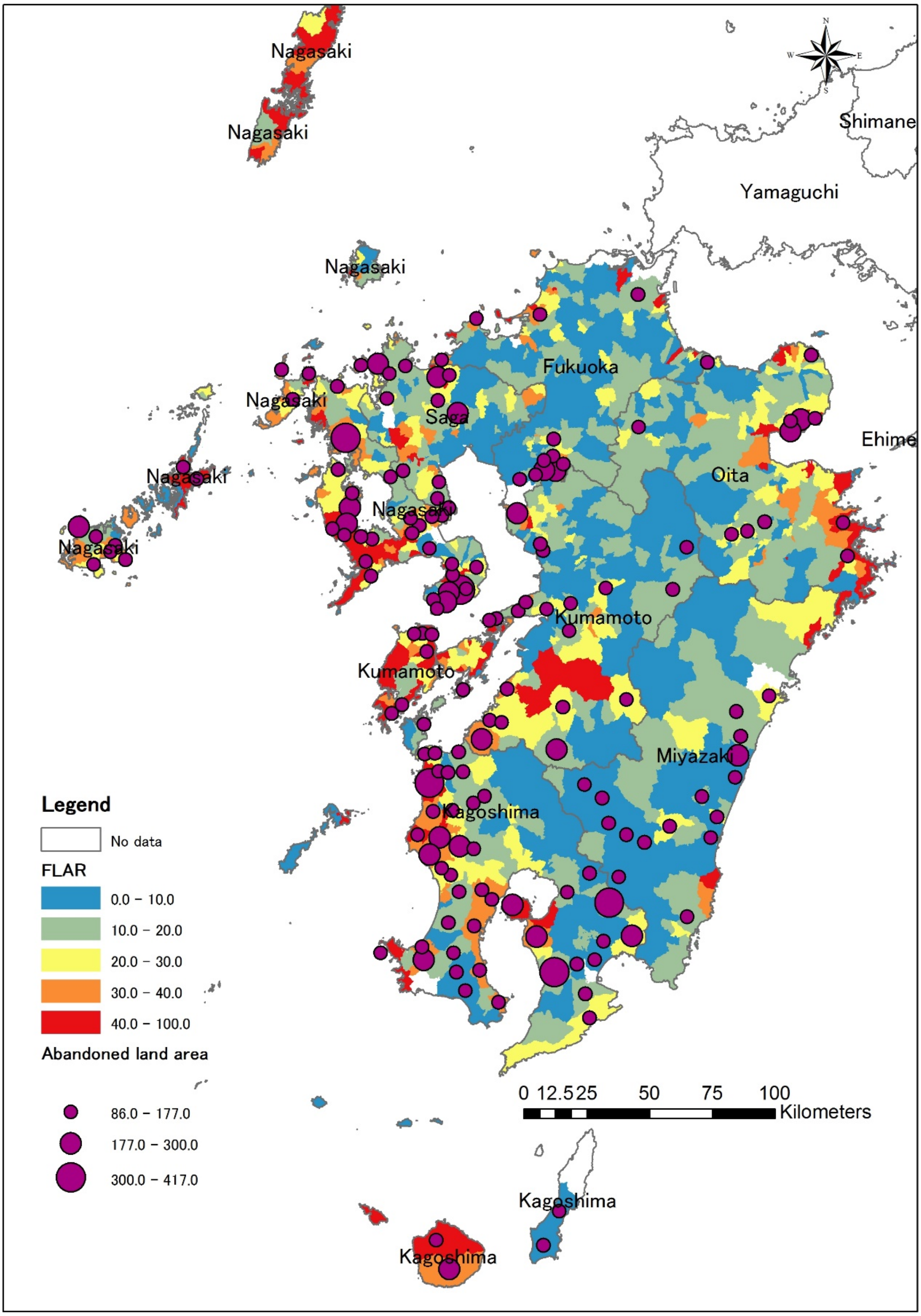
Appendix IV FLAR and FLA area of Chubu Region in 2010



Appendix V FLAR and FLA area of Kinki Region in 2010



Appendix VI FLAR and FLA area of Chugoku/Shikoku Region in 2010



Appendix VII FLAR and FLA area of Kyushu Region in 2010

Appendix VIII Pearson's correlation coefficient among different variables.

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	1											
X2	−0.162**	1										
X3	−0.091**	0.046**	1									
X4	0.254**	0.036**	0.024*	1								
X5	−0.131**	0.015	0.016	−0.014	1							
X6	−0.134**	−0.045**	−0.023*	−0.343**	−0.010	1						
X7	−0.224**	−0.024*	0.003	−0.293**	0.096**	0.331**	1					
X8	−0.234**	0.023*	0.002	−0.128**	−0.027**	0.318**	0.499**	1				
X9	0.236**	−0.071**	−0.035**	0.085**	−0.051**	0.024*	0.013	0.014	1			
X10	−0.088**	−0.052**	0.003	−0.206**	0.413**	0.060**	0.089**	−0.179**	−0.003	1		
X11	−0.192**	−0.025*	−0.013	−0.123**	0.081**	−0.033**	0.163**	0.144**	−0.040**	0.070**	1	
X12	−0.101**	0.014	0.037**	−0.173**	0.191**	−0.018	−0.179**	−0.494**	−0.222**	0.389**	−0.118**	1

Numbers whose absolute correlation value is higher than 0.5 are highlighted in bold font.

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix IX Questionnaire survey to know people's consumption preference and attitude to agriculture (in Japanese)

もし答えたくない場合は999と入力してください

No	質問	答え	選択肢						
1	国籍								
2	性別		1. 男性	2. 女性					
3	年齢								
4	最終学歴		1. 中学校卒業	2. 高校卒業	3. 専門学校・短大卒業	4. 4年制大学卒業	5. 修士・博士課程修了	6. その他	
5	同世帯で生活する人の数								
6	同世帯の子どもの人の数								
7	職業		1. 専業主婦	2. アルバイト	3. 会社員・公務員	4. 自営業（農家以外）	5. 農家	6. 学生	7. 無職・定年後
8	１週間にどれくらいの頻度でジャムを使いますか？								
9	食料品への１か月の支出はいくらですか？								
10	世羅に住んでいますか？		1. はい	0. いいえ					
11	10番がいいえの場合：どこに住んでいますか?（世羅に住んでいる場合は999と入力）								
12	どのようにしてこの道の駅を知りましたか？		1. 友人・親戚から聞いて	2. インターネットで	3. 新聞で	4. 通りかかって	5. その他		
13	どれくらいの頻度でこの道の駅に来ますか？		1. 週一回	2. 月一回	3. 年一回				
14	今日はどの交通手段を使って道の駅に来ましたか？		1. 徒歩	2. バスで	3. 車で	4. バイクで			
15	来るのにどれくらい時間がかかりましたか？								
16	普段どのような農作物を購入しますか？（複数の回答可）		1. 野菜	2. 果物		4. 加工食品（精肉、ハチミツ、豆腐、ジャム）	5. その他（具体的にお願いします）		
17	地元の食べ物を消費する理由を３つ選んでください。		1. 新鮮さ	2. 地元産業の支援	3. 味	4.生産者との繋がりがあるから	5. 栄養	6. 地域経済の支援	7. 安全性
18	日本の農業地帯の多くが深刻な耕作放棄地の問題に悩まされているのを知っていますか？		1. はい	0. いいえ					
19	子どもに将来、農業をしてほしいと思いますか？		1. はい	0. いいえ					

Appendix X Farm household survey questionnaire on agriculture and FLA in Sera (in Japanese)

世羅町の農業と耕作放棄に関する農家調査アンケート

日付: 調査員:

集落名:

1. 回答者の個人情報:

1.1 お名前	
1.2 年齢	
1.3 性別	[1] 男性 [2] 女性
1.4 世帯主との続柄	[1] 世帯主本人 [2] 配偶者 [3] 父または母 [4] 子供 [5] 兄弟または姉妹 [6]その他 [ ]

2. 世帯情報（一緒に住んでいる（同居している方の情報）

NO.	世帯主との続柄	年齢	性別	雇用（パートタイム/フルタイム）	最終学歴（１.中学 2.高校、3.大学あるいは大学院、4.その他）	勤務先/所属先
1						
2						
3						
4						
5						
6						
7						
8						

3. 農業関連の質問

3.1 あなたが農業を行う主な目的は？（最も重要なもの一つに◯）

[1] 農村部での生活を楽しむため [2] 収入を得るため

[3] 祖先から継承された農地を維持するため [4] 自分および家族で食べるため

[5] その他( )

3.2 農業経営の将来計画は？

[1] 規模を大きくする [2] 規模を小さくする
[3] 現状維持 [4] 特に考えていない

"[2] 規模を小さくする"と答えた方は以下の質問に答えてください:

[1] 高齢のため [2] 後継者がいない
[3] 農業の収益が低い [4] 労働力不足
[5] 他に仕事があるため [6] 野生動物の被害
[7] その他( )

3.3 あなたの子供は家の農業をどのくらいの頻度で手伝っていますか？

[1] 頻繁に（同居） [2] 時々（月に 1〜2 回） [3] 農繁期のみ [4] まったくない

3.4 あなたの家の農業後継者はありますか？

[1] はい [2] いいえ [3] 今はまだ考えていない (理由)

4. 土地利用について

4.1 あなたの家で所有している農地面積を教えてください

農地		**ヘクタール (町歩)**
総面積		
耕作している農地	水田	
	畑地	
	樹園地	
耕作放棄している農地（所有している場合）		

4.2 農業生産のために他の人たちに農地を貸していますか？

[1] はい 幾ら(アール) [2] いいえ 注） 1 反は 10 アール

4.3 農業生産のために他の人たちから農地を借りていますか？

[1] はい 幾ら(アール) [2] いいえ 注） 1 反は 10 アール

4.4 世羅町は広島の他の地域と比較して耕作放棄率が低いですが、主な理由は何だと考えますか？

（　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　）

4.5 耕作放棄の主な理由は何だと思いますか？（もっとも重要と考えるもの 3 つに◯）

[1]地域の 過疎化のため　　　　　　[2]農業後継者がいないため

[3]労働力不足　 のため　　　　　　[4] 野生動物被害のため

[5] 農地が遠い　ため　　　　　　　[6] 農業が低収益であるため

[7] 農地に機械が入らないため　　　[8]農地が小さいため

[9] 農業従事者の高齢化のため　　　[10]その他(　　　　　　　　　　)

4.6 耕作放棄防止のための「中山間地等直接支払い政策」についてどう思いますか？

[1] 大変効果がある　　　　[2] 少し効果がある　　　　[3]　あまり効果がない

４まったく効果がない　５知らない

上のように考える理由:

4.7 あなたの家が耕作放棄した場合、その後の土地利用計画は？

[1] 放棄したままにする　　　　　　　　[2] 誰かを利用する人を探す

[3] 再び耕作する（いつ：　　　　　　）　　[4] 他目的で使用する

[5] その他(　　　　　　　　　　　)

4.8 何が耕作放棄を防止する効果的対策になると思いますか？

[1] 各家がもっと努力すべきだ　[2]集落単位の農業を構築する

[3] 他の家の助けを借りる　　　　[4] 政府がより多くの補助金を出す

[5] 他業界の人々の助けを借りる

[6] 十分な労働力を持つ家に農地を貸せるようにする

[7] その他(　　　　　　　　　　　)

4.9　放棄された農地を再耕作する可能性がありますか？

[1] はい　　　　　　　　[2] いいえ

5　その他

5.1　世羅町の耕作放棄に関するご意見、ご提案、ご意見がございましたら、ご記入ください:

Appendix XI Survey questionnaire on the actual condition of ICBFCs and maintenance of farmland in Hiroshima Prefecture (in Japanese)

広島県の集落法人の実態と農地の維持に関するアンケート調査

I.貴法人の概要についてお尋ねします。

Q1-1:貴法人の名称と設立年を教えて下さい。

1 名称（　　　　　　　　　　　　　） 　　　　2 設立年（昭和・平成　　　　　年）

Q1-2:貴法人のタイプを教えて下さい。

1 集落ぐるみ型*　　　2 担い手中心型**　　　3 その他（　　　　　　　）

*集落ぐるみ型 : 地域内の相当数の農家が構成員となり経営に参画して農業経営を行う法人（全戸参加型)。

**担い手中心型 : 大型農家などの担い手（1 戸から数戸）が構成員となり農業経営を行う法人。

Q1-3:貴法人が所在する集落内の全農家数と法人に参加している農家の数をお教えください。

1 所在する集落（　　　　）2 全農家数（　　　　）戸 3 構成員である農家数（　　　　）戸

Q1-4:貴法人における利用権設定農地面積に関する基本情報

現在耕作地		総面積（集積した面積）(ha)
耕作している農地	水田	
	畑地	
	樹園地	
耕作せず管理のみ（休耕地）		
耕作放棄地（法人が管理している場合）		

Q1-5:貴法人の作物作付に関する基本情報

作物	面積(ha)	2018 年支出経費(万円)	2018 年販売額(万円)
水稲			
麦			
大豆			
野菜			
果物			
その他（　　　）			

Q1-6: 貴法人の構成員について基本情報

年齢	法人構成員の人数	常時従事者*の人数	常時雇用者**の人数
30 歳以下	男：　　　女：		
30-40 歳	男：　　　女：		
40-50 歳	男：　　　女：		
50-60 歳	男：　　　女：		
60-70 歳	男：　　　女：		
70 歳以上	男：　　　女：		

*常時従事者とは，法人の構成員（役員含む）であり，法人からの年間収入が概ね 150 万円以上のものをいう。

**常時雇用者とは，法人の構成員ではなく，法人からの年間収入が概ね 150 万円以上のものをいう。

外国人の雇用者がいる場合お答えください。

（国籍と人数:　　　　　　　　　　　　　仕事内容:　　　　　　　　　　　　　　）

Q1-7:使用されている農業機械の台数をお教え下さい。

1 トラクター（所有______台；借用______台）　　2 田植え機（所有______台；借用______台）

3 コンバイン（所有______台；借用______台）　　4 乾燥機（所有______台；借用______台）

5 バインダー（所有______台；借用______台）　　6 耕耘機（所有______台；借用______台）

7 その他 ____________________（所有 ______ 台；借用 ______ 台）

Q1-8:貴法人が<u>過去 3 年間</u>に行政から受けた補助金をご記入ください（複数あればそのようにお答え下さい）。

交付機関および補助事業名	交付開始年月	交付終了年月	金額（万円/年）
	年　　月	年　　月	

II.耕作放棄についてお尋ねします。

Q2-1: 貴法人の農地には耕作放棄地がありますか。

1 ある（　　　　　　　　　ha）　　　　　　2 ない

Q2-2:（Q2-1 ある）を選択された法人にお尋ねします。貴法人は耕作放棄地をどのように管理されていますか（特に重要と考えられるもの<u>三つだけに○</u>をつけてください）。

1 草地や林地にしている　　　　　　　　2 動物が入らないようにしている
3 太陽光発電をしている　　　　　　　　4 水張りをしている
5 景観作物を植栽している　　　　　　　6 何も栽培せず、耕起だけはしている
7 その他(　　　　　　　　　　　　　　　　　　　　　　　　　　　　　)

Q2-3: 貴法人は耕作放棄地を再耕作または再利用したことがありますか。

1 ある(　　　　　　　　　ha)　　　　　2 ない

Q2-4:（Q2-3 ある）を選択された法人にお尋ねします。耕作放棄地を再生する際の最大の課題は何ですか（特に重要と考えられるもの<u>三つだけに○</u>をつけてください）。

1 再生コストがかかる　　　　　　　　　2 要する労働力が多すぎる
3 耕作放棄地の所有権が複雑である　　　4 耕作放棄地が分散しすぎている
5 新しい利用のアイデアが必要である　　6 その他(　　　　　　　　　　　)

Q2-5:貴法人は耕作放棄地についてどう思われますか
（<u>どちらか一つに○</u>をつけて、理由もお答えください）。

1 問題だと思う
2 問題だと思わない

<u>理由</u>

（　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　）

Q2-6:貴法人が所在する地域における耕作放棄の主な理由は何だと思われますか
（特に重要と考えられるもの<u>三つだけに○</u>をつけてください）。

1 地域の過疎化のため　　　　　　　　　2 農業後継者がいないため
3 労働力不足のため　　　　　　　　　　4 鳥獣による被害のため
5 農地が遠いため　　　　　　　　　　　6 農業が低収益であるため
7 農地に機械が入らないため　　　　　　8 農地が小さいため
9 農業従事者の高齢化のため　　　　　　10 その他(　　　　　　　　　　　)

Q2-7:何が耕作放棄を防止するための効果的対策になると思われますか
（特に重要と考えられるもの三つだけに○をつけてください）。

1 個々の農家がもっと努力すべきだ　　2 集落単位で農業を行う
3 他の家の助けを借りる　　4 政府がより多くの補助金を出す
5 他業界の人々の助けを借りる　　6 十分な労働力を持つ家に農地を貸せるようにする
7 その他(　　　　　　　　　　　　　　　　　)

Q2-8:耕作放棄防止との関係で「中山間地等直接支払い制度」についてどう思われますか。

1 聞いたことがない　　2 大変効果がある　　3 少し効果がある
4 あまり効果がない　　5 まったく効果がない　　6 何とも言えない

Q2-9:耕作放棄防止との関係で「米の生産調整政策」についてどう思われますか。

1 聞いたことがない　　2 大変効果がある　　3 少し効果がある
4 あまり効果がない　　5 まったく効果がない　　6 何とも言えない

III. 貴法人をとり巻く状況についてお尋ねします。

Q3-1: 貴法人は他の法人と何らかの連携をとっていますか。連携がある場合には、連携法人の数を（　）内にご記入ください。

1 ある（　　　　　　）　　2 ない

Q3-2:（Q4-1 ある）を選択された法人にお尋ねします。どのような連携を行っていますか（あてはまるものすべてに○をつけてください）。

1 機械の貸し借り　　2 作業の受委託　　3 共同販売　　4 その他（　　　　　　　　）

Q3−3:貴法人は農家を集めた研修会をどのような頻度で開催していますか。

1. 年 1〜3 回　　2. 年 3〜5 回　　3. 年 5〜10 回
4. 年 10 回以上　　5. なし

Q3−4:研修会のテーマを教えてください（あてはまるものすべてに○をつけてください）。

1 農業技術　　2 新しい品目　　3 法人の経営管理
4 鳥獣による被害へ対策　　5 販売（マーケティング，物流）
6 農産物の生産･品質管理　　7 その他（　　　　　　　　　　　　　　　　）

Q3−5:集落法人のメリットについて、どのように思われますか
（特に重要と考えられるもの<u>三つだけに○</u>をつけてください）。

1 個人の農家より労働力が確保しやすい
2 農業のコスト低減効果が大きい
3 過疎化した集落を守る効果がある
4 耕作放棄地を抑制し農地の保全ができる
5 集落農家間の相互交流が活性化する
6 大型機械化により作業効率が向上する
7 その他（　　　　　　　　　　　　　　　　　）

Q3-6:貴法人は農地の維持のために、どのようなことをしていますか
（特に重要と考えられるもの<u>三つだけに○</u>をつけてください）。

1 減農薬栽培あるいは有機農業
2 稲作以外の多様な農作物の栽培
3 景観を美しくする作物の栽培
4 野生動物を避けるためのフェンスの設置
5 経営の複合化や六次産業化
6 その他（　　　　　　　　　　　　　　　　　）

Q3-7:貴法人は将来の発展に向けて、今後どのようなことをしようとしていますか
（特に重要と考えられるもの<u>三つだけに○</u>をつけてください）。

1 減農薬栽培あるいは有機農業
2 稲作以外の多様な農作物の栽培
3 地元の大学や研究所との協力
4 経営の複合化や六次産業化
5 法人外の農家との良好な関係の維持
6 法人財政の改善
7 農業に役立つ先端技術の利用
8 その他（　　　　　　　　　　　　　　　　　）

Q3-8:貴法人の発展にとって、課題と考えていることをあげてください
（特に重要と考えられるもの<u>三つだけに○</u>をつけてください）。

1 実務を担う人材や後継者の不足
2 高齢化で農作業ができない人の増加
3 法人の維持費用が負担
4 輸送や市場出荷における利便性の悪さ
5 政府の補助金に依存した経営
6 農業政策の先行きが不透明
7 農産物の価格の不安定
8 農地の分散による農作業効率の悪さ
9 法人経営に無関心な人の増加
10 その他（　　　　　　　　　　　　　　　　　）

Q3-9:貴法人の活動、地域の耕作放棄地と農地の管理などについて、ご意見や提案があればお聞かせください（自由記述）

IV.法人の代表者及び将来の後継者についてお尋ねします。

Q4-1:貴法人の代表者について以下のことを教えて下さい。

性別： 1 男性　2 女性　　**年齢:**（　　　　歳）

世帯構成:1. 独身　2.夫婦のみ　3.夫婦と子　4.三世代　5.その他（　　　　　　）

最終学歴：1 中学校　2 高校　3 短大　4 大学以上　5 その他 (　　　　　　)

前職：（　　　　　　　　　　）

Q4-2:貴法人の経営を今後中心になって担う後継者がいらっしゃいますか。

1 いる　　2 いない　　3 まだ考えていない

*質問は以上です。お忙しい中、ご協力まことにありがとうございました。

3 月 15 日（金）までに返信用封筒に入れて、ご投函ください。