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Research Summaries

2025

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Preface

The Korea Rural Economic Institute (KREI), a government-funded research institute specializing in agriculture, rural areas, and the food industry, is committed to enhancing the capacity of Korea's agri-food sector to respond to uncertainty and to revitalizing agriculture and rural communities through new growth engines. Over the past year in particular, the Institute has conducted research on a wide range of topics, including strategies for reducing overseas forest carbon emissions using REDD+, measures to improve the sustainability of forest product production through the adoption of open-field smart agriculture technologies, and the socio-economic effects of increasing the living population in rural areas, along with related policy directions.

This volume summarizes and presents the key findings of 26 basic and general research reports published in 2025. It aims to provide a concise overview of the research outcomes, enabling readers to easily access and understand the reports. For more detailed information or to engage with the researchers, please refer to the contact information provided in each summary. Full reports are also available on the Institute's website.

We would like to express our sincere appreciation to the related organizations for their guidance and valuable advice throughout the research process, to the farmers who actively cooperated in the surveys, and to the researchers who devoted their best efforts despite challenging conditions.

We hope that this volume will serve as a useful resource for understanding the Institute's major research outcomes in 2025 and for broadening perspectives on the pressing issues facing agriculture and rural communities.

March 2026

President, Korea Rural Economic Institute HAN Doobong

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Transnational Forest Carbon Mitigation Strategy through REDD+

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Purpose of Research

- This study aims to diagnose the institutional, economic, and social limitations of REDD+ and to propose a practical overseas forest-based carbon mitigation portfolio that integrates agroforestry as a strategic pathway for Korea's NDC achievement.
- Specifically, the research identifies the structural sources of REDD+ inefficiency and analyzes the mechanisms through which agroforestry can complement these weaknesses.
- It also quantitatively compares the efficiency, risk, and economic performance of agroforestry-integrated REDD+ with conventional standalone REDD+, and explores the institutional, financial, and

governance arrangements required to link overseas REDD+ outcomes with Paris Agreement Article 6 (ITMO) and national GHG accounting (NDC).

Research Method

- A mixed-method approach was employed, combining literature and case analysis with econometric and scenario-based modeling. Case studies from Nepal, Indonesia, Cambodia, and Zambia were used to identify structural constraints related to land tenure, governance, and livelihood systems.

- Field visits, expert interviews, and document analysis were conducted to supplement these findings. A stochastic frontier analysis (SFA) was performed using 140 global REDD+ projects, examining the effects of project size, crediting period, forest enhancement activities, technical training, corruption levels, and agroforestry variables on project efficiency.

- In parallel, REDD+ and agroforestry scenarios were designed for Laos' Phongsaly Province?ranging from pure teak plantation (A), short-cycle agroforestry (B), long-cycle agroforestry (C), to deforestation-adjusted extensions (A2, C2).

- These were evaluated through NPV estimation, Monte Carlo simulations incorporating carbon price uncertainty, first- and second-order stochastic dominance tests, and certainty-equivalent (SERF) analysis.

Main Findings

- The empirical findings indicate that REDD+ projects face clear performance limits when relying solely on forest conservation or plantation-based approaches.
- Institutional weakness, insecure land tenure, insufficient incentives, limited participation, and inequitable benefit distribution emerged as core bottlenecks.
- SFA results showed that long-term project duration, forest enhancement activities, and capacity-building significantly improved efficiency, while higher corruption levels increased inefficiency.
- Agroforestry did not drastically increase average emission reductions; rather, it served as a "risk-buffering mechanism," stabilizing project outcomes and reducing performance volatility.
- In the Laos scenario analysis, long-cycle agroforestry (C, C2) consistently outperformed pure plantations (A, A2) in NPV, stochastic dominance, and certainty-equivalent measures over a 30-year horizon.
- However, over extended periods (60?80 years), high-density plantations (A2) displayed greater long-term carbon-stock potential, emphasizing the need for a time-differentiated portfolio strategy: agroforestry for short- and medium-term performance, and afforestation for long-term carbon banking.

Policy Suggestions

- Policy implications highlight the necessity of incorporating agroforestry as a core element in Korea's overseas REDD+ cooperation.

- First, REDD+ must transition from a narrow conservation project model to a structural reform program that integrates land tenure clarification, anti-corruption safeguards, decentralized governance, and livelihood diversification.

- Second, Korea's overseas forest strategy should adopt a dual-track approach: agroforestry-based REDD+ as the main vehicle for achieving 2030 NDC targets, and afforestation-based REDD+ as a long-term carbon reservoir for 2050 carbon neutrality.

- Third, to formally account for agroforestry-based REDD+ outcomes in NDC inventories, advanced baseline setting, deforestation-rate modeling, multidimensional MRV (including non-carbon indicators), Article 6-compliant corresponding adjustments, community-based benefit-sharing structures, and blended-finance mechanisms (ODA·climate funds·private investment) must be established.

- Finally, REDD+ should evolve from a collection of discrete "good projects" into a systemic pillar of Korea's climate and forest policy, supported by expanded stochastic dominance analyses across countries, socio-economic and gender impact assessments, and dynamic modeling of ITMO and blended-finance mechanisms.

- The results collectively underscore that combining REDD+ with agroforestry is not merely an option but a strategic necessity for achieving robust, equitable, and scalable overseas carbon mitigation outcomes aligned with Korea's climate commitments.

Policy Strategies to Enhance the Sustainability of Non-Timber Forest Product Production through Open-Field Smart Agriculture Technologies

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Purpose of Research

- The objective of this study is to propose a direction for smart mountain-type forestry that can enhance the productivity and sustainability of forest product production by restructuring open-field smart farming technology to suit the mountainous environment. The forest product production industry is facing a structural crisis as the climate crisis, labor force reduction, and consumption contraction emerge simultaneously. Mountainous

areas are subject to greater constraints of slope and accessibility, making cultivation more difficult than in open fields, and thus require more precise and smart management. However, smart farming has developed primarily for agriculture, with standards tailored to farmland, and forest product production has been excluded from the policies of the Ministry of Agriculture, Food and Rural Affairs. The Korea Forest Service has also not sufficiently promoted the digital transformation of the production sector, leaving a significant gap. Accordingly, this study evaluates whether open-field smart farming technologies-such as soil sensors, weather sensors, pest/disease sensors, drones, operating machinery, video monitoring, and automatic control devices-can be utilized in mountainous areas. Furthermore, it reviewed the feasibility of their adoption and complementary elements based on mountainous characteristics like slope, accessibility, communication infrastructure, and ownership structure. The ultimate goal of this research is to present concrete directions for the smart transformation of forest product cultivation based on these analyses.

Research Method

- This study analyzed technological, human, and institutional factors together to evaluate whether open-field smart farming technology can operate in mountainous areas and to propose directions for the smart transformation of the forest product production industry. The analytical framework was structured into the Technology Axis, the Society Axis, and the Resistance Axis, based on the perspective that smart transformation requires the collection, judgment, and execution of information to be connected in a single

flow, which must be supported by a delivery system responsible for implementation in the field. The Technology Axis examined the applicability of core technologies (soil, weather, and pest/disease sensors, drones, video monitoring, automatic control devices, etc.) to mountain-type conditions. The Society Axis verified the recognition, learning, and utilization levels of foresters and diagnosed the functionality of the delivery system, including local organizations and cooperation structures. The Resistance Axis analyzed the structural constraints of mountainous areas, such as slope, accessibility, communication networks, costs, and institutional limitations.

Main Findings

- This study examined the three axes of Technology, Society, and Resistance together from the perspective of observation, judgment, and execution to reveal why the smart transformation of the forest product production industry is delayed. The analysis subjects consisted of policy data, statistics, spatial information, forester surveys, on-site opinion gathering by product type, and cases from Japan, Finland, and Estonia. Through this multi-layered analysis, the structural causes preventing technology from functioning in the forest product production industry were systematically confirmed.

- The forest product production industry was situated in a policy structure disconnect. The Ministry of Agriculture, Food and Rural Affairs possessed the foundations for observation, judgment, and execution but failed to institutionally include forest product production, while the Korea Forest Service promoted digitalization

centered on administration and disaster response, with production technology remaining in the initial stages. Both ministries lacked structures to support technology diffusion and social learning, causing the smart transition to stop at the starting line.

- Field management conditions formed a structure difficult for technology adoption. The average area was small, around 1 hectare, multi-parcel management was common, and constraints on slope and accessibility were significant. Labor was concentrated in the elderly and family units, and the distance between forest land and residence resulted in observation, judgment, and execution being carried out in a disconnected manner. These conditions were fundamental constraints making it difficult to form an automated and data-driven production system.

- Forester demand analysis showed significant dropout at the introduction and learning stages, and utilization, sharing, and service industries were barely functional. The adoption rate was around 10%, learning experience and utilization levels were low, and the proportion of non-use of equipment was very high. The sharing infrastructure could not be formed due to the absence of organizations and cost burden. This indicates that the core reason is not a technology performance issue but a social bottleneck due to a lack of opportunities and spaces to learn and utilize the technology.

- Infrastructure diagnosis confirmed a structure where technology introduction did not lead to diffusion due to a lack of foundations for observation, judgment, and execution. The lack of observation foundation prevented the opening of adoption

pathways, the structure connecting judgment and execution was absent, and the automation foundation was also weak. Physical, economic, and institutional constraints overlapped, preventing the connection of technology, people, and organizations.

- The delivery system, which is a key axis for technology diffusion, was instead operating as a bottleneck. Neither the forest management guidance officers nor the agricultural technology centers performed the technology delivery function of connecting observation, judgment, and execution in the forestry sector, and the social cycle supporting foresters' adoption, learning, utilization, and sharing was not functional. Functions to alleviate field constraints were also insufficient.

- International case studies commonly confirmed that the structure in which technology operates is more important than the technology itself. Japan created a field-based structure of repeated demonstration, learning, and sharing, and gradually integrated technology, legislation, industry, and data onto it to resolve bottlenecks. Finland and Estonia designed a structure where observation information, administration, industry, and citizens moved as a single system, establishing an environment where information collection, judgment, and execution routinely circulated. These comparative results clearly demonstrate that structural transition is necessary to resolve Korea's dual ministerial system, confusion in field administration, dispersed forest owner structure, lack of social acceptance, and absence of a delivery system.

Policy Suggestions

- The core problem of smart forestry is not a lack of technology but the absence of a structure for technology to operate. Observation, judgment, and execution are disconnected; the paths for foresters to learn and maintain technology are severed; and public and private delivery systems are not functioning, often causing technology to halt upon reaching the field. Therefore, what is needed is not the supply of equipment, but a structural reform that simultaneously transforms the policy foundation, technology infrastructure, social diffusion pathways, and delivery organizations. From this perspective, the study derived four strategies and fourteen tasks.

- First, the Strategy for Policy System Linkage includes expanding the national foundation already established by smart agriculture to forestry, combining technology, data, and standards into a single structure, and clearly realigning the roles of the Ministry of Agriculture, Food and Rural Affairs, the Rural Development Administration, and the Korea Forest Service. Second, the Strategy for Building Mountain-Specific Technology Infrastructure is to redesign observation technology, judgment technology, and execution technology to suit mountain-type conditions, predicated on constraints in slope, communication, and power, and to establish a technical structure where the three stages circulate. Third, the Strategy for Restoring Social Diffusion Pathways involves restoring the foundation of people, organizations, and markets to prevent disruption in technology adoption, learning, utilization, sharing, and service creation, and activating collaboration and the private service ecosystem. Fourth, the Strategy for Delivery System Innovation is to set professional

delivery organizations as the central axis, reallocate roles between the public and private sectors, and connect field organizations and national platforms into a single data structure. These four strategies and fourteen tasks are essential preconditions for transitioning smart forestry from a technology-centered approach to a structure-centered national strategy, and only when this foundation is prepared will the technology be able to operate in the actual field.

Socio-Economic Impacts of the Increase in the Living Population in Rural Areas and Policy Strategies

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Purpose of Research

- To address the accelerating depopulation and aging of rural areas, as well as the concentration of firms and population in the Seoul metropolitan region, the government has sought to introduce an alternative demographic concept as a basis for policy transformation. However, both the national living-population system and local-level programs remain in their early stages and exhibit several limitations. Enhancing the effectiveness of government policies requires diverse research efforts, including quantitative analyses of living-population trends and case studies on the effectiv

eness of related programs and institutional frameworks. This stu dy aims to examine the current status and changes of the “living population,” identify the economic and social conditions under which an increase in the rural living population contributes to r egional revitalization, and propose strategies to promote such c ontributions.

Research Method

- A review of the literature was conducted to examine the academic discussions and policy evolution related to the concepts of “related population” and “living population,” and relevant laws, institutional frameworks, and policy documents from central and local governments were analyzed to establish a conceptual framework. Based on living- population statistics, the study conducted a quantitative analysis of the economic effects of the rural living population. To identify the determinants of rural residents’ acceptance of the living population, a survey of 735 residents across six townships was administered. To assess the social effects of the living population, written and interview-based investigations were carried out on major policy cases such as the Two-Region Living program and Youth Villages. Synthesizing these results, the study derived policy implications for enhancing the socio-economic contributions of the living population in the context of rural revitalization.

Main Findings

- In Korea, the concept of the "living population" was institutionalized through the enactment of the Special Act on the Support of Population- Declining Areas, and 146 local governments have established relevant ordinances. The government's First Basic Plan for Responding to Population-Declining Areas (2022-2026) positions rural extinction as a national strategic issue, focusing on expanding the living population, activating regional stays, and fostering related populations. Various initiatives—such as the Local Extinction Response Fund, Go to Hometown projects, stay-type rural complexes, and vacant-house regeneration—are being implemented. However, many projects remain facility-oriented and short term, with weak linkages between related populations and local communities.

- In Japan, the concept of "related population" emerged in the mid- 2010s from the earlier idea of "exchange population," referring to individuals who maintain continuous emotional and social ties with a region. Institutionalized through the national Regional Revitalization Strategy, it has been further advanced via the Digital Garden City Nation Initiative (2023-2027), which leverages digital technology to broaden regional connectivity. Ministries such as the Cabinet Office, Ministry of Internal Affairs and Communications, and Ministry of Agriculture, Forestry and Fisheries collaborate to operate programs including Regional Revitalization Cooperation Teams, Hometown Working Holidays, and Corporate Hometown Tax schemes. These are supported by local coordinators and intermediary organizations that promote sustained engagement—implications that suggest Korea must evolve its living-population policy toward strengthening qualitative

relational ties.

- Using experimental statistics that integrate administrative, telecommunications, and consumption data, the study quantitatively analyzed the economic effects of the living population with 2024–2025 panel data. The results showed that as the living population increased, monthly average credit-card spending per capita also rose, with revisit rates and average length of stay exhibiting the strongest economic impacts. Quantile regression further confirmed that higher revisit rates and longer stays had significant positive effects across consumption levels. These findings indicate that the continuity and quality of engagement, rather than sheer population size, play a more critical role in influencing local economies.

- From a social perspective, the expansion of the living population contributed to greater cultural diversity and stronger external networks in rural communities. However, in some areas, the influx of outsiders was perceived as competition by residents, generating social tensions. This underscores the need to institutionalize mechanisms such as relationship guides, resident–visitor partnership communities, and intermediary support organizations. Educational initiatives and joint programming to improve residents' acceptance of outsiders are also essential, ensuring that living-population policy evolves from visitation-centered strategies to those fostering sustainable community building.

- Many living-population programs were still structured around short stays or tourism-based participation, limiting their ability to build durable community relationships. Some local governments

distorted policy intent by setting targets based solely on migration or settlement figures. Future policy should shift toward a living-population–resident partnership model, positioning living populations not as consumers but as collaborative partners in community development. To this end, living-population councils, linkages to local food and community currency systems, online–offline hybrid exchange spaces, and intergenerational mentoring and talent-sharing networks were presented as key tasks.

Policy Suggestions

- Korea's demographic policies have long focused on quantitative population growth through fertility promotion and migration incentives. However, analysis of living-population statistics indicates that the key drivers of meaningful economic impact are qualitative elements such as revisit rates and average length of stay—not the number of visitors. Policy should therefore be designed as a "ladder of relationships," turning one-time visitors into fans, and fans into core partners. Programs that promote sustained engagement—such as local cultural and ecological immersion activities, long-stay programs, and workation-based experiences—should form the backbone of this approach.

- Survey findings reveal that rural residents often perceive visitors as consumers or competitors for local resources, posing potential barriers in the expansion of the living population. Yet cases like Youth Villages and Live in Sangju demonstrate that the primary contribution of the living population lies in social vitality rather than consumption. Thus, policy should redefine the living population

based on "what they can do together with the community," not simply what they consume. Models such as talent-exchange living programs (e.g., Jeonchecharep) or Talent Bank initiatives that match urban expertise with rural needs can enhance meaningful contribution and increase local acceptance.

- Findings also show that the success of living-population policy depends more on operational and intermediary organizations than on physical infrastructure. Sangjudaum, functioning as a relationship office and coordinator, played a bridge-building role by connecting urban youth with local residents and resources. In Japan, platforms such as Kakawari Lab facilitated the development of NPO-led intermediary organizations. Future policy should cultivate these relationship-building intermediaries, support their activities through online platforms, and strengthen horizontal collaboration across existing community-based networks.

- A major strength of Korea's living-population policy is its ability to measure target populations quantitatively using telecommunications and consumption big data. To enhance its utility, current county-level statistics should be disaggregated to township or "living-zone" levels for more precise local policy design. Supplementary surveys are needed to classify motivations for visits and provide differentiated policy responses. Additionally, institutional mechanisms should be established to support the use of these data in central grant allocation, Local Extinction Response Fund distribution, and preliminary feasibility studies.

Workforce Development for Smart Agriculture across Farmers, Extension and Advisory Personnel, and Industry

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Purpose of Research

- This study aims to identify policy tasks to improve current curricula and build a workforce development system for smart agriculture by (1) comprehensively reviewing the current status and operation of education programs for smart-agriculture workforce, such as farmers, extension and advisory personnel, and industry professionals; (2) diagnosing and assessing the competencies required for each type of workforce professional; and (3) using these findings to help create the foundations required to maximize the impact of smart-agriculture adoption

and foster it as a future growth industry.

Research Method

- This study combined a literature review, analysis of microdata from existing surveys (secondary data), a structured survey, job vacancy postings, in-depth interviews, and an expert consultation. First, through a literature review and expert consultation process, we organized the current status and operation of smart-agriculture education provided by central and local governments, universities, and public institutions, and analyzed domestic and international cases. Second, using external survey microdata, the study survey, and job vacancy data, we conducted a detailed diagnosis of farmers' smart-farm utilization capacity and education, and the characteristics of firms employing smart-agriculture industry personnel and their in-service training. Lastly, we conducted in-depth interviews with 50 stakeholders, including farmers, consulting personnel, employees of smart-agriculture firms, central and local government officials in charge of education programs, public institutions, and other experts, to identify the field-level context and constraints on policy implementation.

Main Findings

- Smart-agriculture workforce development policies have been implemented along three main pillars: farmers, farm support personnel, and the industry personnel. In the early stages, policies focused mainly on providing standardized education; however, over time, the scale and diversity of training instruments have expanded and become more sophisticated. Farmer-oriented policies have evolved toward (1) the quantitative expansion of basic

education, such as designating and operating specialized training institutions, and (2) the expansion of practice-based curricula aimed at raising the technological level, including joint advanced-technology training centers and field-based training programs. For farm support personnel, policies initially focused on strengthening the capacity of public extension officers at local agricultural technology centers but later shifted toward defining core competencies and introducing certification schemes to standardize consulting services and establish quality-control systems. In the industry workforce domain, support has evolved from programs centered on training master-level personnel (at the graduate level) to demand-driven systems that cover both in-service training and the recruitment of new entrants.

- Compared with education for farm support or industry personnel, farmer training is conducted at multiple levels by the central government and local governments. However, apart from training offered by smart-farm incubator centers and a few provincial-level programs for young farmers, most training courses are short-term and fragmented by the provider. Long-term programs conducted by incubator centers or provincial agricultural research and extension services primarily target those aged 39 or under; some include farmers up to the age of 50 years. Considering the current age distribution of farmers and the age profile of greenhouse farmers adopting smart horticulture, broadening target groups and designing age-specific programs is necessary. To enhance the effectiveness of incubator center training, issues such as strengthening the expertise of implementing agencies, securing budgets for facility maintenance and repair, expanding

training items and content, and reinforcing follow-up support functions (e.g., expanding the role of incubator centers) have been raised, calling for further policy discussions.

- Education for farm support personnel can largely be summarized as follows: (1) capacity building for public-sector rural extension officers and (2) quality assurance for private-sector trainers and consultants through the introduction and operation of certification systems. Because the quality of smart-agriculture education and consultation is one of the key factors determining the performance of farms adopting the technology, local governments must devote greater attention, budget, and human resources to expanding and upgrading capacity-building programs for extension officers in provincial agricultural research and extension services. Under the First Basic Plan for Smart Agriculture Promotion, each metropolitan and provincial government is required to formulate its own plan, placing greater emphasis on strengthening the competencies of rural extension officers. Additionally, it is necessary to continuously monitor the operation of the Smart Agriculture Manager (smart-farm consultant) certification system to ensure the quality of education and consulting services.

- In the industry workforce domain, major programs include in-service training for employees of smart-farm information and communications technology (ICT) firms and scholarship-type programs for training master's- and doctoral-level personnel. Because training provided solely by the Korea Smart Farm Industry Association (hereafter, the industry association) is insufficient to significantly enhance the competencies of firm employees,

establishing regional hub training institutions is necessary. Moreover, considering the intensifying climate change, global diffusion trends, and domestic policy directions, smart agriculture is expected to continue expanding. In-service training alone will not suffice in securing the required number and quality of professionals. Accordingly, it is necessary to clearly define the core competencies demanded by the industry and incorporate smart-agriculture workforce development functions into the formal education system by establishing multi-layered articulation pathways—such as specialized high schools–junior colleges, high schools–universities, and high schools–universities–graduate school tracks. This requires inter-ministerial collaboration and further research.

- Currently, farmers are adopting and operating smart-farm systems more frequently in both single-span and multi-span plastic greenhouses (32.9% and 65.6%, respectively) than in glass greenhouses. Specifically, 60.6% of single-span plastic greenhouses lack automated environmental control functions, which should be considered when designing training content. The overall technical level among smart-farm farmers is polarized, and 30.3% were found to have generally low competence in smart-farm utilization. Overlaps between crop seasons and training schedules, mismatches between training content and on-farm conditions, and the absence of training providers in some regions were identified as factors that discouraged participation. Therefore, education for farmers should (1) provide separate tracks by facility type and technical level, (2) adjust training frequency based on farm-level demand, and (3) strengthen incentives for

participation in areas where farmers' competencies are weak by systematizing the training structure.

- Smart-agriculture education and consulting were derived from farm-level demands. In addition to the farmers' capacity to operate smart farms, consultants require distinct competencies, such as an understanding of smart agriculture–related policies and support programs and advanced academic or practical experience (e.g., a PhD degree or equivalent consulting experience). The survey and interview results demonstrate broad recognition in both the public and private sectors of the need for training and capacity development for consultants, suggesting the importance of establishing systematic capacity-building programs for smart-agriculture consulting professionals.

- Smart agriculture-related firms tend to have relatively short operating histories, reflecting their industry characteristics. Because personnel have largely been recruited in response to on-site demands, there is still a shortage of workers whose job competencies have been systematically developed through formal education. Consequently, on-the-job training is unavoidable. However, many firms are small or micro-sized, which likely constrains their internal training capacities. Moreover, the types of businesses conducted before entering the smart-agriculture field are diverse, creating a necessity for retraining to support incumbent workers' job transitions. Nevertheless, externally offered in-service training is heavily concentrated in programs provided by the industry association. Therefore, it is necessary to designate specialized regional training institutions to expand

the training supply and improve association-based training by diversifying delivery methods and designing level-specific modular curricula.

- Given the expected growth in smart agriculture, integrating industrial workforce development functions into the formal school system is also necessary. The core of such programs is to clearly define the required competencies and classify them according to difficulty level. Analysis of job vacancy postings revealed a strong demand for (1) knowledge and skills at the hardware, software, and data interfaces; (2) knowledge and skills related to agriculture and crop production using smart-farm facilities; and (3) practical on-site experience. The demand was particularly specific in the ICT/software and data/artificial intelligence job categories, in which firms sought skills closely aligned with their detailed business domains. School-based programs should reflect these features and be designed as modular curricula structured around "job category × required skills × difficulty level."

- A comprehensive review of domestic and international smart-agriculture workforce development cases has several implications for establishing Korea's workforce development system. First, an integrated governance structure is necessary. As illustrated by Japan's Smart Agriculture Innovation Council and the Netherlands' Education–Extension–Research linkage system, workforce development should be designed as a nationally coordinated effort rather than a collection of fragmented initiatives by individual institutions. Second, mid- to long-term, demand-driven

strategies are required. As seen in the European Union's Smart Agricultural Knowledge and Innovation Systems and Korea's smart-manufacturing initiatives, competencies required at each stage of industry development should be defined in advance, and curricula must be developed accordingly. Third, practice-oriented, field-linked training systems should be strengthened. Fourth, decentralized regional hubs should be established to enable training that reflects local crop patterns and industrial conditions. Fifth, a data-based educational infrastructure and sharing system should be developed. Platforms that utilize real-world field data in training, such as Japan's WAGRI and the Netherlands' Join Data, can significantly improve educational effectiveness.

Policy Suggestions

- The basic directions for workforce development to support the foundation of smart agriculture can be summarized as follows: First, a standing inter-ministerial coordination mechanism should be established. Because smart agriculture is a convergent industry that integrates ICT-based hardware and software, and the resulting changes in employment structures cannot be addressed solely within the agricultural sector, cross-government collaboration is essential. Second, multilayered governance and a clear division of roles and functions among actors must be established. Considering the diversity of workforce types and crop-specific characteristics, it is most effective to promote workforce development within a multi-layered system that connects central and local (metropolitan and basic) governments, universities, specialized training institutions, and industries based on

role-sharing and coordination. Third, the continuous strengthening of linkages among actors is required. Within this multi-layered governance structure, stakeholders should be connected through standing consultations and coordination bodies to ensure ongoing alignment between field-level demand and national standards.

- The detailed policy tasks for farmer workforce development are as follows: First, education for farmers must be systematized by developing modular, level-specific curricula based on the dimensions of "provider (central vs. local government) × target group × crop × facility type × training content × competency level." Second, the capacity and infrastructure of smart-farm incubator centers should be strengthened, and the effectiveness of their training should be improved. This requires (1) enhancing the professionalism of program management, (2) securing realistic mechanisms to share the costs of facility maintenance and repair, and (3) expanding the scope of training to include smart-farm facility construction and the utilization of facility types other than glass greenhouses, such as multi-span plastic greenhouses. Third, the smart-agriculture education infrastructure and competency frameworks should be improved by building and operating an integrated smart-agriculture education platform and upgrading and activating crop-specific competency maps. Fourth, education and training for professional farmers must be improved. This includes establishing smart-agriculture tracks that link agricultural high schools and colleges of agriculture, expanding the field-training infrastructure at agricultural universities, and promoting credit exchanges with institutions that provide industry workforce training.

- The quality of smart-agriculture education and consulting directly affects farm adoption performance. Therefore, the Rural Development Administration and provincial agricultural research and extension services should expand training for extension officers at municipal and county agricultural technology centers and actively use smart- agriculture test-bed training facilities within these centers to strengthen field-level advisory capacity. In the private sector, dedicated programs for training smart-agriculture education and consulting professionals should be established and implemented to improve service quality. Additionally, a talent pool of smart-agriculture consultants should be created, and a competency management system should be introduced to track the participation history and continuing professional development records of registered consultants. Furthermore, the Smart Agriculture Manager certification system must be continuously systematized and upgraded. To respond to farm-level demand, the supply base for farm support personnel trained through school education should be expanded, and new train-the-trainer programs should be introduced and systematically operated to strengthen the competencies of instructors and trainers (i.e., faculty and field trainers) who deliver such education.

- The detailed policy tasks for industry workforce development are as follows: First, the effectiveness of the in-service training provided by the industry association must be enhanced. Despite the limited annual inflows of new employees owing to the small scale of many smart-agriculture firms, current training is heavily skewed toward basic courses. Training curricula should be redesigned to gradually reduce the share of introductory courses,

expand intermediate and advanced programs, and improve delivery methods by offering classes outside working hours and online options. Second, a region-centered system for delivering job training should be established. Currently (excluding programs under other ministries), in-service training for employees is limited to courses provided by the industry association, which constrains access for firms located outside the capital region. Regional hub institutions for industry workforce training should be designated and nurtured to promote decentralized provision. Third, job competencies should be designed based on an analysis of job vacancies. Common and job-specific competencies should be translated into level-specific modular curricula, and both the association and regional hub institutions should apply common standards (i.e., learning objectives, performance indicators, and assessment rubrics). Fourth, in the formal education system, contract-based departments should be used to develop work-study models tailored to industry requirements, and multiple employment pathways should be provided to advance the sophistication of industry workforce development systems.

Current Status and Policy Challenges of the Root and Tuber Crops Industry

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Purpose of Research

- Root and tuber crops such as potatoes and sweet potatoes are among the major food crops, with demand increasingly diversified across households, food manufacturing, and food service industries. However, maintaining the production base for these crops has become a critical challenge amid changing conditions, including declining yields due to climate change, potential increases in imports driven by evolving trade environments, rising production costs, and growing difficulties in securing agricultural labor. Although the government has implemented various policies, most remain at an embryonic stage and insufficiently reflect the unique characteristics of root and tuber crops.

Research Method

- The study primarily employed the following methodologies: a comprehensive review of domestic and international literature, analysis of statistical data, examination of relevant laws and institutional frameworks, in-depth interviews with key stakeholders in the root and tuber crop industry, focus group interviews, surveys targeting both producers and general consumers, and expert consultations.

Main Findings

- Potato consumption can be broadly categorized into three segments: for household food use, for food processing, and for food service. Among these, demand for processed and food service uses has been steadily increasing. While domestic processors generally prefer locally produced raw materials, the scheduled phase-out of seasonal tariffs (beginning in 2026) and the volatility in domestic yields are expected to heighten competition with imported products. Distinct regional production zones exist depending on cultivation type, and demand characteristics differ accordingly. Nonetheless, the potato industry has faced widening yield fluctuations due to climate change, increased import variability, rising production costs, and growing difficulties in securing labor in a timely manner, thereby escalating management risks. In summary, the major challenges facing the potato industry include the following: (Demand-side issues) insufficient transmission channels for diversified consumer demand, limited producer awareness of product differentiation, and constraints on processors' ability to secure stable domestic raw materials. (Trade-related risks) potential decline in production value following seasonal tariff elimination,

and concerns over the importation of genetically modified (LMO) potatoes. (Supply-side issues) difficulties in securing seed potatoes, inadequate measures to cope with climate change and pest outbreaks, and labor shortages coupled with slow progress in mechanization.

- Sweet potato consumption is primarily divided into food and processing uses, with increasing demand for the latter. Unlike potatoes, the proportion of domestically sourced sweet potatoes is relatively high; however, the industrial demand base remains weak due to limited specialization of end uses. Although the cultivation area has gradually expanded, the industry faces similar challenges—yield variability due to climate change, import fluctuations, increased management costs, and rising labor shortages. Key challenges include the hollowing: (Demand-side issues) insufficient market channels to reflect diversified demand, and the small scale and low capacity of processing enterprises. (Supply-side issues) bottlenecks in seed sweet potato supply, inadequate adaptive measures for climate and pest risks, and persistent labor shortages with limited mechanization.

Policy Suggestions

- This study proposes five policy directions to enhance the competitiveness and sustainability of the potato and sweet potato industries, along with detailed recommendations for each.

- Responding to Changes in Consumption Patterns and Demand: Policies should adapt to evolving consumer preferences and

market diversification. Efforts are needed to develop new varieties that meet diverse consumer needs and establish a production foundation enabling farmers to cultivate various cultivars, promote technological innovation and production system transformation to ensure stable output and improved quality. Specific measures include 1) establishing voluntary commodity associations or revitalizing regional producer organizations in major producing areas to serve as hubs for consumer promotion and producer education, and 2) strengthening the seed distribution system by expanding varietal diversity through public-sector supply while incentivizing private participation in seed development and information sharing. Integrating new seed cultivation trials with on-site agricultural mechanization demonstration projects to better reflect field-level needs. For sweet potatoes, focusing on exploring new markets by promoting their potential use as industrial raw materials.

- Strengthening the Production Base Against Climate and Environmental Risks: To mitigate the impacts of exogenous factors such as climate change, 1) developing heat- and moisture-tolerant varieties suited to changing environmental conditions, and 2) promoting wider utilization of agricultural meteorological disaster early-warning systems and enhance participation incentives by linking such systems with crop disaster insurance programs.

- Addressing Labor Shortages and Enhancing Mechanization: A systematic approach is needed to improve labor supply and the use of agricultural machinery while fostering producer organization as follows: 1) Expand the public seasonal worker program as a

responsive measure to on-farm labor shortages in upland crop production. 2) Encourage collaboration among local farms, producer groups, cooperatives, and agricultural associations to establish coordinated labor-sharing systems. 3) Recognize mechanization not merely as a means of labor reduction but as a complementary labor strategy, promoting collective farming models and region-wide mechanization projects to enhance equipment utilization rather than ownership.

- Preparing for Trade Liberalization and Production Base Contraction: In anticipation of declining production value and potential erosion of the domestic production base following tariff elimination, the following measures are proposed: 1) For potatoes, extend the expiration of the FTA Damage Compensation Program to offset losses due to the abolition of seasonal tariffs. 2) Differentiate domestic potatoes from imported genetically modified (LMO) varieties by emphasizing food safety and quality attributes. 3) Foster contract farming through storage facility support, enhanced training for participating farmers, dissemination of standard contracts, and establishment of dispute mediation mechanisms.

- The distribution system for root and tuber crops requires comprehensive review and improvement. The current distribution structure, which is heavily dependent on wholesale markets, poses limitations to the stabilization of farm management, primarily due to significant fluctuations in market prices. To address these challenges, it is necessary to assess the feasibility of introducing online wholesale market mechanisms and to explore the diversification of distribution channels. Such diversification

should be pursued on the basis of organized producer groups in major production areas, which can enhance bargaining power and efficiency in distributing activities.

Securing the Growth Base of Livestock Industry in Response to Workforce Shifts

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Purpose of Research

- This study focuses on the following three areas in response to changes in the workforce structure. First, it presents efficient utilization plans for livestock facilities slated for closure and those already abandoned. It specifies models for 'succession, sale, and lease' to connect idle facility resources, resulting from aging farmers and a lack of successors, to new entrant young farmers or existing farmers seeking expansion. Furthermore, for long-term abandoned facilities, it proposes utilization plans and reversion plans to create a virtuous cycle for these resources. Second, it examines strategies to expand the adoption of smart livestock farming using ICT. It analyzes policy support measures

and tasks to accelerate the dissemination of smart livestock technologies—which are key to improving productivity, optimizing animal management, and solving odor and biosecurity issues—and to increase their on-site application. Through this, it seeks strategies for the technological advancement of the livestock industry. Third, it derives measures for securing new farmers. To fundamentally address the problems of aging and labor shortages and to improve the quality of the livestock labor force, it comprehensively reviews improvement plans to support the stable entry and successful settlement of the younger generation into the livestock industry.

Research Method

- This study adopted a mixed-methods research design combining literature reviews, legal and institutional analysis, quantitative and qualitative field surveys, and spatial database analysis using GIS to analyze the multi-faceted issues of the livestock industry.

- First, through literature and legal analysis, it reviewed key regulations related to livestock facilities, succession-related policies, and abandoned facility policies. It also analyzed cases of new entrant promotion and succession support in the US, EU, and Japan.

- Second, a survey of existing livestock farms was conducted, targeting 501 farms nationwide (251 Hanwoo, 50 dairy, 50 pig, 50 broiler, 50 layer, 50 duck). The main survey contents included farm status, management difficulties, labor structure, aging and

succession plans/obstacles, and the status and barriers of ICT smart farming adoption.

- Third, a survey of prospective entrant farmers was conducted, targeting 66 students in livestock-related departments at the Korea National University of Agriculture and Fisheries, a future source of manpower. The main survey contents included perceptions of the livestock industry, intention to enter, key barriers, and policy demands.

- Fourth, as a key methodology, a spatial analysis was performed using the livestock farm database from the FAHMS. Instead of simple changes in the number of farms, it identified farm identification numbers of 'closed (transferred, sold) farms' and 'new (succeeded, purchased) farms'. Furthermore, by cross-analyzing farm number history and GIS coordinates, it determined whether new farms were located on 'existing livestock facility sites' or 'new livestock facility sites'. This quantified the actual recycling rate ('utilized as barns') and neglect rate ('not utilized as barns') of closed facilities by livestock type.

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Main Findings

- The findings showed that the aging rate of livestock farms outpaced that of other agricultural sectors. As of 2023, the aging rate (65+) of livestock farms was 54.1%, which increased by an average of 4.8% annually from 29.6% in 2010, faster than the total farm average (2.8%). The generational gap has already become a reality; the survey of existing farms revealed that 69.7% of respondents had no successor, and 67.9% of those had no plans to find one. The biggest reason for the lack of successors was 'poor working conditions' (65.9%), while the top reason for difficulty in succession even with a successor was the 'tax burden related to gifts and inheritance' (63.8%), indicating dual barriers in both entry and succession. A gap between aging farmers' retirement plans and reality was also confirmed. While 'sale to a third party' (52.5%) was the most desired plan post-retirement, the main source of retirement income was 'personal pensions and savings' (62.7%), with 'income from farm sale or lease' accounting for only 13.6%. This signifies a failure in asset liquidation, where farm assets fail to function as a means to secure retirement funds.

- This labor exodus directly leads to the large-scale idling of facilities. The FAHMS-GIS data analysis quantitatively proved that in the recycling status of closed farm sites, nearly 90% of assets for most livestock types were not recycled and remained abandoned (not utilized). Over 4 years, a total of 21,151 Hanwoo farms closed, but only 9.2% were re-utilized as barns, while 90.8% remained abandoned. For dairy farms, 87.9% were unutilized, 90.7% for broiler farms, and 83.2% for layer farms. In contrast, pig farms had a relatively higher recycling rate, with 31.6% of the

1,233 closed farms being utilized. This was presumed to be due not to asset value, but to the 'permit value', as new permits are virtually impossible to obtain. This waste of resources led to inefficiencies in new entries. While abandoned barns were left neglected, 86.4% of 14,359 new Hanwoo farms built new facilities on 'new sites' rather than existing ones, and 80.1% of new dairy farms also located on new sites. This signifies duplicate capital investment and a failure in resource allocation.

- Barriers to new entry were also found to be entrenched. The survey of livestock-majoring university students showed they rated the 'importance of the industry' (98.5% positive) highly, but 77.3% responded negatively regarding 'economic stability'. 'High initial investment costs' and 'difficulty securing barns and land' were overwhelmingly cited as the biggest obstacles to entry. The most needed policies were also 'financial support' and 'facility acquisition support'. Notably, 75.0% of prospective entrants hoped to 'utilize existing barns/land' due to the burden of new construction costs, but in the actual market (FAHMS data), 86.4% of new Hanwoo farms were building on 'new sites', confirming a gap between the hopes of new entrants and reality.

- Meanwhile, the adoption status of ICT smart livestock farming, emerging as an alternative for labor saving, was found to be stalled at '1st generation' technology, failing to maximize efficiency. Adoption was concentrated on simple remote monitoring and automation technologies like 'automatic feeders/waterers' (75.0%) and 'CCTV' (64.3%). The adoption of '2nd generation' (data-based) technology was only 15%. Farmers perceived 'high initial adoption

costs' (79.8%) as the biggest obstacle.

Policy Suggestions

- To solve the problems derived from the findings, workforce disconnection, asset circulation failure, technology stagnation, the following policy measures were proposed.

- First, the establishment of a 'Livestock Housing Bank' is proposed. This can serve as an integrated hub to simultaneously solve the problems of asset liquidation for aging farmers (retirement support) and entry barriers for young farmers (asset acquisition), becoming key infrastructure for a virtuous cycle of disconnected resources. The Bank would perform functions as an information platform by building a nationwide livestock facility database and disseminating a 'standard appraisal model'; it would mediate between sellers and buyers and provide legal/tax consulting. Furthermore, it would directly purchase/stockpile viable idle facilities, remodel them into ICT smart barns, and lease or sell them to young farmers at low interest under an 'asset-light' model. It would also support the demolition (reversion) of non-viable or environmentally problematic facilities in connection with the 'Rural Spatial Rearrangement Project'.

- In the technology sector, to overcome the stagnation at 1st generation smart farming, the policy focus must shift from simple hardware dissemination to support for data utilization consulting and operation services. This requires activating a 'Smart Agriculture Manager' certification system and establishing data

standardization by livestock type and a big data platform to foster an ecosystem for private-sector AI analysis services.

- In the personnel sector, solving capital and location barriers is urgent. The asset-light entry model via the 'Livestock Housing Bank' lease program should be primarily supported, and a financial safety net should be established, offering a chance to recover from failure (e.g., sale-and-lease-back to the Bank). Also, unrealistic requirements for the agricultural inheritance deduction must be relaxed. Finally, a spatial solution must be sought by designating 'livestock zones' in remote areas isolated from residential areas and preemptively developing smart livestock complexes with

Forest and Mountain Village Revitalization Strategy in Response to Local Decline

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Purpose of Research

- Local depopulation and the decline in rural mountain communities represent urgent policy challenges. Demographic contraction and population aging manifest with particular severity in mountain villages, primarily due to weak industries and the inadequate provision of educational and living services. The shrinkage of these communities has triggered transformations in land-use patterns and led to the neglect of forest management, thereby compromising forest ecosystem services and undermining territorial management.

- This study was undertaken to illuminate the potential of forests and mountain villages to address local depopulation and explore

pathways for local revitalization. Specifically, the study endeavors to articulate policy directions, vision, objectives, and implementation strategies for forest and mountain village plans amid the crisis of mountain village extinction.

Research Method

- The methodological framework encompassed a comprehensive utilization of literature review, statistical data analysis, quantitative modeling, survey research, and case studies. Initially, literature and statistical data were analyzed to diagnose the current status of forests, mountain villages, forestry and wood industries, and to evaluate relevant policies. A cohort analysis was employed to examine demographic transitions and to project future population trajectories in mountain villages. Spatial regression analysis was applied to identify the determinants of population change in mountain villages. Furthermore, a survey of 1,000 adults was conducted to investigate public perceptions and expectations regarding forests and mountain villages. External conditions surrounding the forests, including climate change, biodiversity considerations, and evolving demands for forest resources, were systematically documented. Additionally, forest policies and local revitalization cases in Japan, Germany, France, and Austria were examined. Drawing on these analytical findings and survey results, and considering the internal and external environmental transformations affecting forests and mountain villages, a long-term strategic plan was formulated.

Main Findings

- Forests occupy approximately 63% of the territory, but weak linkages between forestry and wood industries result in a domestic wood self-sufficiency rate of merely 17%. Low wood prices relative to high production costs render forestry uncompetitive, hindering sustainable forest management, and accelerating economic stagnation in mountain villages. The government announced policies to tackle local depopulation, focusing on employment creation utilizing local resources and expanding tourism infrastructure. The Korea Forest Service has also presented the Basic Forest Plan and Basic Mountain Village Promotion Plan to revitalize mountain villages.

- Population decline and aging in mountain villages have positioned numerous communities at high risk of extinction. Demographic contraction reduces the provision of essential living services and weakens local resilience. Nevertheless, mountain villages possess abundant ecological resources, and diverse cases are seen to leverage these assets for community revitalization, encompassing not only forestry, but also tourism, mountain sports, and the energy utilization of forest biomass.

- Spatial regression analysis was employed to identify the spatial characteristics that influence demographic changes in the mountain villages. Employment availability is a critical determinant. The analysis confirmed that mountain villages with more businesses(employment) experienced population growth among individuals aged 50-70. Agricultural land area demonstrated positive effects on population growth in the 60-70 age cohort. Meanwhile, the scale of forest-based enterprises has emerged as

a significant factor in population growth among those aged 50-60, underscoring the importance of forest business creation for community revitalization.

- Public perceptions and expectations regarding forests and mountain villages warrant particular attention. Citizens value forests as environmental and public-benefit assets. More than 65% of the respondents indicated that forest policy should prioritize environmental protection over economic utilization, identifying "forest ecosystem conservation and biodiversity" as the primary policy areas. Most citizens perceived mountain villages as spaces for forest recreation and outdoor activities. While many express interest in relocating to mountain villages, "insufficient living infrastructure" was identified as the principal barrier to migration.

- Climate change and the biodiversity crisis responses are essential considerations in planning. Forests and mountain villages play crucial roles in addressing these challenges. Forest carbon offset projects and OECM(Other Effective area-based Conservation Measures) can be leveraged for forest community revitalization. Additionally, emerging demands from urban residents for forest recreation and relocation to mountain villages represent opportunities.

- Case studies from abroad have demonstrated the value of forests and mountain villages through diverse policies. Japan targets green growth in forestry and new value creation in mountain villages, specifically promoting wood use in buildings, a vision of a Digital Garden City Nation, corporate participation in biodiversity enhancement, and local vitalization cooperator corps. Germany

emphasizes the multifunctional benefits of forests, sustainable forest management, wood use, and the bioeconomy as core pillars of local revitalization, while operating subsidy programs that support climate-adaptive activities by forest owners. France has increased wood harvesting and promoted material and energy use to activate forest-based economies. Austria centers on social forestry connecting forests' multifunctional benefits with local economies, particularly linking forest healing and tourism with forests. Japan and Europe cases provide valuable insights into the creation of forest businesses.

Policy Suggestions

- Considering the aforementioned investigations, analyses, and internal and external environmental changes, a long-term plan for forests and mountain villages is proposed. The vision articulates "sustainable forests and mountain villages characterized by self-reliance, circulation, and coexistence," with objectives encompassing attractive mountain villages, profitable forestry or forest businesses, and nature-positive outcomes. The four core implementation strategies are as follows:

- First, growth and circular management in forestry and wood industries should be carried out. This requires the construction of sustainable forest management systems, fostering domestic wood use, and integrating biodiversity into forest and forestry policies. Forestry must be reformed to secure the support of local communities.

- Second, diverse forest businesses that utilize local resources should be cultivated. This involves promoting circular forestry, in which locally harvested wood is used within the local for materials or energy. The creation of various forest businesses, including forest education and mountain sports, and advancing digitalization, such as smart forestry and remote work arrangements, should be pursued.

- Third, the value and attractiveness of the mountain villages should be enhanced. This necessitates accommodating diverse lifestyles, generating connection populations by linking forest properties with tourism, and pursuing urban-rural coexistence through PES agreements or attracting corporate ESG activities.

- Fourth, local-based forest management systems should be established. This requires the redefinition of mountain villages through municipality-based designation and the provision of corresponding incentives, including mountain village revitalization funds and direct public payments. In response to decentralization policy trends, local governments should establish local forest management plans.

Capital Investment by Agricultural and Food Corporations and Policy Suggestions

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Purpose of Research

- To enhance the growth and profitability of agricultural corporations, it is essential to expand investment, which serves as the driving force for growth. Although investment involves risk and does not necessarily guarantee improvements in profitability or growth, numerous studies have demonstrated its positive effects. Therefore, without sufficient capital input to achieve scale expansion and facility improvement, it will be difficult to expect future profits.

- However, the amount of capital investment by agricultural corporations has been on a declining trend. This decline is presumed to have weakened their profitability and growth potential, yet no quantitative analysis has been conducted to determine whether such a reduction in investment has had an actual impact, and if so, to what extent. While the relationship between capital investment and profitability has been empirically examined for general corporations, there is a lack of corresponding research for agricultural corporations. Moreover, the impact of investment scale on profitability and growth may vary depending on the type of asset, but studies addressing this issue are also limited. Therefore, it is necessary to analyze how capital investment affects the profitability and growth of agricultural corporations and to comprehensively examine the factors contributing to their low investment levels.

- The purpose of this study is to evaluate the effects of capital investment by agricultural corporations and to identify internal and external challenges to revitalizing such investment. Specifically, it quantitatively analyzes whether capital investment has contributed to improving the management performance of agricultural corporations and examines its role in fostering their growth. In addition, the study seeks to identify the causes of declining investment levels and diminishing investment effects, and to explore strategies to expand capital investment both quantitatively and qualitatively, ultimately promoting the sustainable growth of agricultural corporations.

Research Method

- This study broadly examines all agricultural corporations in relation to general institutional frameworks and overall trends. However, for in-depth analyses, including interviews, the focus is placed on production-oriented corporations—such as those engaged in crop cultivation (food and horticulture) and livestock farming—as well as food companies that face difficulties in attracting external capital. This focus reflects the fact that many agricultural businesses expand into upstream industries based on their agricultural operations. In addition, the "investment" addressed in this study refers to expenditures that agricultural corporations make on tangible assets for the purpose of expanding scale or modernizing facilities, which is considered distinct from external capital investment in agricultural corporations.

- Capital investment by agricultural corporations can be divided into facility investment (tangible assets) and technology development investment (R&D and other intangible assets). This study limits its analysis to facility investment. Technology development investment differs in nature from facility investment and requires a long period for outcomes to materialize. In addition, the level, scope, and spillover effects of technology development vary significantly across business areas, making quantitative comparative analysis difficult. Moreover, for agricultural corporations whose primary business lies in production, securing tangible assets in the short term is considered a more critical issue than technology development. For these reasons, this study focuses primarily on facility investment.

- The research methodology consists of literature review, quantitative analysis, qualitative analysis, and expert consultation. For the literature review, prior studies on the relationship between capital investment and financial performance, as well as literature related to policies promoting capital investment, were examined. For the quantitative analysis, financial data of agricultural corporations from 2014 to 2023 were used to analyze the impact of asset investment on managerial performance. The dependent variables are indicators representing the financial performance of agricultural corporations—namely, profitability and growth measures. The explanatory variables include a facility investment indicator dummy as the key variable, along with firm characteristics, financial stability indicators, and external environmental variables. The qualitative analysis involved visiting or, when necessary, conducting telephone interviews with 22 corporations located across various regions, targeting CEOs and financial management personnel of agricultural corporations. Lastly, expert consultations were conducted with specialists in agricultural corporation systems to obtain policy recommendations regarding institutional improvements for capital procurement and expansion of investment in agricultural corporations.

Main Findings

- Over the past decade, agricultural corporations have achieved outward growth, but their growth momentum has gradually slowed. Indicators of scale—such as assets, capital, and sales—have generally increased, whereas indicators of growth and profitability have steadily declined. In terms of financial stability,

although the level of leverage remains high, the stability indicators themselves have shown gradual improvement.

- Under these circumstances, investment activities have been identified as a key factor determining the growth potential of agricultural corporations. As the number of investments increases, the likelihood of advancement to a higher growth stage also rises. Regression analysis results indicate that investment activities have a positive impact on both profitability and growth indicators. Thus, while facility investment plays a critical role in the growth of agricultural corporations, it also entails financial burdens, demonstrating a dual nature.

- On average, most agricultural corporations appear to remain in the "growth pressure" stage (Stage 3 in this study's growth-stage classification). Although some corporations are growing rapidly, the majority remain small in scale and seem to be losing growth momentum. To restore their growth drivers and enhance management performance, it is crucial to identify the factors influencing both investment and business outcomes. Overall, corporate performance can be viewed as the result of internal and external factors operating through investment. Conversely, business performance also affects investment decisions, as improvements or deteriorations in performance determine whether subsequent investments are made. In the long run, this creates a cyclical relationship between management performance and investment. Accordingly, internal and external factors influence both investment and performance, generally in the same direction.

Policy Suggestions

- The revitalization of investment by agricultural corporations ultimately requires an approach that considers not only short-term increases in investment but also long-term sustainability. Accordingly, the government should intervene in the market only to the extent that it does not undermine market principles, and should improve its support mechanisms so that firms can grow naturally through competition. It is necessary to reduce agricultural corporations' dependence on government support by changing the methods and criteria used for providing financial assistance, enabling them to become self-sustaining. It would be desirable to align the financial support system with the independence of the business entities, shifting toward a model in which additional incentives are granted to corporations that prepare for growth on their own and actually achieve it. Furthermore, it is important to facilitate the entry of the next generation of agricultural corporations. Instead of a proliferation of numerous small and vulnerable firms, policies should be designed to promote the sustainable growth of a smaller number of sound agricultural corporations, thereby strengthening the overall foundation of the sector.

- As detailed policy tasks to achieve these goals, this study proposes the following:

  ① establishing a system for identifying and supporting high-performing agricultural enterprises to create an environment conducive to providing incentives;

  ② fostering a self-reliant culture of managerial risk management by supporting the accumulation of operating funds;

③ encouraging more prudent use of government funds by strengthening eligibility requirements for subsidy programs and setting upper limits on subsidy rates;

④ enhancing the financial management capability of agricultural corporations by improving the funding acquisition and financial management competencies of managers;

⑤ recognizing business succession as equivalent to start-up creation and including succession within start-up support programs; and

⑥ supporting market development activities, including export promotion, for agricultural corporations.

Current Status of Agricultural Debt and Policy Implications for Farm households

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Purpose of Research

- In general, the expansion of capital investment is essential for industrial growth; however, growth in the agricultural sector driven by capital investment has stagnated since the late 2000s. Moreover, the aging of the agricultural labor force and the stagnation in the inflow of new workers have further threatened the future sustainability of agriculture. To promote agricultural growth through increased capital investment, it is desirable to encourage efficient investment expansion led by young and middle-aged farm operators who tend to exhibit stronger investment willingness than their older counterparts.

- In this context, it is necessary to analyze the current state and characteristics of capital investment among agricultural enterprises to assess whether debt is being utilized in a sound and productive manner. Debt serves as virtually the only external source of financing for agricultural enterprises, functioning as leverage to enhance profitability, yet at the same time, it poses risks to financial stability through interest payments and other financial burdens. As uncertainty in the agricultural production environment increases and internal and external conditions lead to potential debt distress, the sustainability of agricultural management could be threatened—particularly among large-scale, professional farm enterprises with higher income and extensive cultivated areas. Therefore, it is essential to identify and analyze the characteristics and debt patterns of vulnerable farms to prevent professional agricultural enterprises from deteriorating into marginal operations that have lost repayment capacity.

- Accordingly, this study analyzes and diagnoses the current debt status of agricultural enterprises under rapidly changing domestic and international conditions, and proposes policy measures to ensure that farm debt is managed soundly and contributes to sustainable agricultural growth.

Research Method

- To achieve its objectives, this study employed a combination of statistical analysis, econometric modeling, literature review, in-depth surveys, and interviews.

- Statistical and econometric analyses were conducted using data from Statistics Korea's Farm Household Economy Survey to examine the typology of agricultural enterprises, current debt conditions and their determinants, dynamic patterns of change, and the factors influencing entry into and exit from marginal management. The analytical framework incorporated multinomial and ordered logit models, survival analysis, and complementary log-log (Cloglog) models. The literature review examined previous studies and analyzed domestic and international cases of financial risk mitigation policies to derive policy implications. In-depth surveys and interviews were conducted to investigate the debt status of young farmers, a group for which official statistics are limited.

Main Findings

- The main findings of this study are as follows. First, the asset and debt structures of farm households differ according to management type, educational attainment, and age, showing a clear trend of polarization by age group. This suggests that, for agricultural growth, it is necessary to alleviate the concentration of assets among elderly farmers and promote asset accumulation and business succession among younger and middle-aged farmers. Although the share of large-scale investment-oriented and stable farms has increased—indicating gradual improvement in the overall financial soundness of the agricultural sector—small-scale investment-oriented farms remain exposed to potential financial risks due to their high debt ratios.

- Second, while the probability of entering a marginal management status has not significantly increased, once entered, the likelihood of recovery has become increasingly difficult in recent years. The analysis shows that older farmers are less likely to fall into marginal conditions and, if they do, are more likely to recover. In contrast, professional full-time farms face a higher risk of marginalization and lower chances of recovery, while part-time farms with larger business scales exhibit lower entry probabilities but even lower exit probabilities once marginalized. Among financial indicators, income was found to be the only factor that both reduces the probability of entering marginal status and increases the likelihood of recovery. This finding underscores the importance of policies aimed at enhancing total household income to support stable debt management among agricultural enterprises.

- Third, financial risk mitigation policies in Korea's agricultural sector are based on broad and generalized legal frameworks, and current rehabilitation programs focus primarily on debt refinancing, limiting their effectiveness in improving financial soundness. In contrast, domestic and international financial risk mitigation systems operate under clear legal bases with institutionalized rehabilitation and debt adjustment mechanisms. This suggests the need to strengthen the agricultural sector's financial resilience through the establishment of clear legal foundations and permanent rehabilitation programs.

- Fourth, survey results from young farmers reaffirmed the critical importance of income. Higher household income was associated

with greater debt repayment capacity and a lower likelihood of ceasing agricultural activities. This indicates the need for policies that enhance total household assets and income to strengthen young farmers' repayment ability and continuity in farming, as well as the development of differentiated financial support programs tailored to successor and start-up farmers.

Policy Suggestions

- Based on the research findings, farm debt management policies should be pursued in the following directions. First, debt management policies should primarily target professional agricultural enterprises that are financially exposed to significant risks.

- Second, financial support programs linked with private financial institutions should be developed to facilitate smooth financing for professional agricultural enterprises—the core group in agricultural production—according to their stage of growth.

- Third, a customized support system should be established that combines permanent institutional mechanisms with special measures, supported by proactive funding plans, to enhance resilience against external shocks and to facilitate both recovery and orderly exit when necessary.

- In the short term, policy financing mechanisms should be differentiated from private-sector lending practices. Growth-stage-specific support programs should be developed, and post-

startup funding schemes should be improved. Moreover, an early warning system for policy finance should be established to detect and mitigate financial risks among agricultural enterprises at an early stage.

- In the medium to long term, key policy tasks include strengthening rehabilitation programs to ensure financial soundness across the business lifecycle, introducing installment-based risk management mechanisms, revising legal frameworks for more systematic policy support, developing integrated platforms to enhance access to policy finance, and reforming governance structures to improve coherence and effectiveness in policy implementation.

A Study on Measures to Address the Non-Tariff Barriers in Agri-Food Export Markets

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Purpose of Research

- As the global agri-food trade environment evolves rapidly, the importance of agri-food export trade has grown. With intensifying global market competition and major trading countries reinforcing various non-tariff barriers (NTBs) to protect their domestic industries, Korean agri-food products face growing challenges in accessing overseas markets. In this context, systematic research on NTBs is not only timely but also essential for strengthening national agri-food export policy. In particular, NTBs in the agri-food sector have become a major constraint on K-Food exports, which are gaining global attention. Accordingly, this study aims to present policy directions to strengthen the global

competitiveness of Korean agri-food products. It seeks to establish a stable export foundation by analyzing the characteristics and influencing factors of NTBs. Ultimately, the goal is to position agriculture as a future growth sector through the sustainable expansion of K-Food.

Research Method

- To identify the current status of non-tariff measures (NTMs) affecting agri-food exports and propose countermeasures, this study employs multiple research methods, including literature reviews, compilation of statistical data, quantitative analysis, expert consultations, and corporate surveys. First, literature from domestic and international sources was reviewed, and statistical data for the empirical analysis were compiled. Based on the collected data, the relationship between NTMs and K-Food exports was quantitatively analyzed. Major cases of NTMs were selected and various econometric techniques were applied to develop an NTMs index. This study aims to empirically identify the impact of NTMs on K-Food exports.

- Expert advisory meetings on NTMs were held to improve the validity and robustness of the study. Finally, pre-interview investigations and surveys were conducted targeting agri-food export companies. These efforts helped ensure the validity and relevance of the survey items while comprehensively identifying how companies respond to NTMs and the policy support they require.

Main Findings

- Discussion on NTBs developed under the framework of the GATT/WTO multilateral trading system. Moving forward, trade agendas related to NTBs are expected to focus more on improving existing regulations in response to the changing environment, rather than venturing into entirely new areas. Moreover, the multilateral trading system will continue to ensure the transparency and legality of NTBs and reinforce relevant rules to prevent their misuse as disguised protectionism.

- As the importance of ESG management has been increasingly emphasized, small- and medium-sized agri-food export companies face several constraints. Therefore, to successfully implement ESG practices, government support policies and voluntary efforts by businesses must be combined. The government should establish regular consultation channels with the relevant departments in major export destinations to share early regulatory changes and support businesses' practical responses. Companies, for their part, should strengthen cooperation networks with partner countries and swiftly acquire information on regulatory changes, to flexibly adapt to rapidly changing regulatory environments and secure a sustainable export base in the medium to long term.

- A survey of NTMs in major export destinations across mature, emerging, and potential markets showed that NTMs encompass a wide range of policy measures that serve different purposes. Among these initiatives, technical measures such as SPS and TBT are the most common, with most international trade being regulated to some extent by technical barriers. The ad valorem equivalents (AVEs) of NTMs on processed food and beverages

vary by category. For SPS measures, the AVEs were 12.3% and -2.8%; for TBT measures, 13.8% and 1.0%; and for pre-shipment inspection and other measures, 7.8% and 4.9%, respectively. Among detailed types, the AVEs were the highest for food safety labeling, packaging requirements, other production and post-production process requirements, product technical regulation labeling/packaging requirements and requirements for sampling, testing, inspection, evaluation, verification, and certification. NTMs have been found to reduce trade volumes. Significant declines were observed in cases involving cold pasteurization, irradiation, fumigation treatment, production and post-production process requirements, specific import permits or licensing requirements, and manufacturing, transport and storage regulations. Conversely, trade volumes increased when new sanitary/phytosanitary rules, product quality, safety, and performance standards and designated customs ports were applied.

- According to a survey on how agri-food exporters respond to tariff and non-tariff barriers, companies handling fresh produce most frequently encountered SPS measures because of the nature of agricultural goods. In contrast, companies handling processed foods faced TBT measures more often. Both types of measures were rated as highly important. In addition, the survey found that the responses to NTBs varied by product and exporter type, highlighting the need for tailored support programs. Furthermore, government support initiatives should prioritize programs with proven effectiveness. They should establish customized information systems that account for differences in information access by company size and develop practical external support measures,

such as expert matching and consulting, to address the structural vulnerabilities faced by small- and medium-sized companies.

Policy Suggestions

- (Strengthen international cooperation channels) In the context of global NTMs discussions, most NTMs aim to achieve legitimate and important policy objectives; therefore, abolishing them is not the solution. Instead, international cooperation is essential for reducing trade costs through transparency, simplification, and the adoption of good regulatory practices, thereby increasing predictability in trade.

- (Respond proactively to new forms of NTBs) Recently, trade measures for environmental purposes have rapidly emerged, raising concerns about their potential to become new NTBs. The EU is promoting the standardization of ESG-related trade regulations through initiatives such as the Green Deal, Carbon Border Adjustment Mechanism (CBAM), and Corporate Sustainability Due Diligence Directive (CSDDD). As ESG policies progress, small- and medium-sized enterprises (SMEs) in the agri-food sector face stricter environmental and sustainability standards, requirements for carbon emission management in production processes, and demands for biodiversity preservation. Preemptive measures by the government or voluntary efforts by businesses are necessary to prevent confusion among SMEs.

- (Establish a real-time monitoring system and unified information hub for agri-food NTBs) There is a need to integrate global NTB

data and develop a platform specialized in the agri-food sector that updates and monitors NTB status by country and product in real time. Additionally, a system should be established to promptly notify exporters of changes in sanitary, phytosanitary, technical, and environmental regulations in target markets. Furthermore, a joint NTB reporting center should be established and operated by the Korea Agro-Fisheries & Food Trade Corporation (KOTRA) and the Ministry of Agriculture, Food, and Rural Affairs to collect and analyze on-site difficulties reported by exporters.

- (Systematically link and utilize information from various sources) Information on overseas NTBs is highly complex and rapidly changing, making it difficult for SMEs in the K-Food sector to respond quickly. Thus, there is a need to gradually interlink and utilize multiple domestic public websites and portals. This information system can be used in a four-step process: early warning, regulation confirmation, verification and certification, response, and case analysis.

- (Foster experts with specialized knowledge and operate joint public-private education programs) With increasingly complex policies and regulations concerning food safety, technical regulations, environmental standards, and carbon criteria, basic trade knowledge alone is insufficient for entering agri-food export markets. Therefore, it is essential to train personnel who understand the policies and regulations of the various target markets and possess strong response capabilities.

- (Enhance tailored consulting and certification support based on product and company characteristics) Customized support programs

for agri-food exporters can contribute to stable market entry and a sustainable export foundation. These programs play a key role not only in short-term performance but also in strengthening long-term global competitiveness. The survey results showed that the types of NTBs and response strategies differed depending on product and company characteristics. Thus, a support system tailored to company size is necessary. Moreover, as NTBs vary depending on product type and processing stage, differentiated strategies and support policies based on product characteristics are required.

- (Build a comprehensive agri-food export company database to improve policy effectiveness) A well-structured database is required to support meaningful surveys and analyses for K-Food export policies, including NTB countermeasures. This database should systematically connect company characteristics, key export products, market information, export difficulties, and policy requirements to provide a comprehensive understanding of export activities at the company level. More precise policy-targeting and performance evaluation systems can be established by linking and integrating survey results with administrative and trade statistics.

Policy Tasks for Persistence in Inorganic Fertilizer Industry

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Purpose of Research

- The purpose of this study is to propose tasks for securing the persistence of the domestic inorganic fertilizer industry in response to changing conditions, including declining demand for inorganic fertilizers due to the reduction of agricultural land area, instability in raw material supply and prices caused by international geopolitical uncertainties, and changes in consumer demand. Although multiple factors are required to maintain the industry, the establishment of a stable supply chain is essential. Accordingly, this study aims to present measures for the persistence of the inorganic fertilizer industry with a focus on building a stable supply chain. To establish a stable supply chain, it is necessary to secure raw materials, enhance efficiency in production and distribution, and reflect the demands of domestic consumers and export markets. Therefore, this study

examines the current status and problems across three segments—raw material procurement markets, domestic production and distribution markets, and domestic consumption and export markets—and then proposes corresponding policy measures.

Research Method

- This study investigates the inorganic fertilizer industry by reviewing prior research, relevant literature, and associated policies. Statistical data from the Korea Fertilizer Association and NongHyup Economic Holdings are used to analyze raw material prices, country-specific production, imports, and domestic production and consumption. Time series analysis, combined with farmland projections, is applied to forecast total inorganic fertilizer usage over the next ten years. A survey of farmers is conducted to assess actual usage and perceptions, particularly for four types of compound fertilizers with limited official data. Finally, domestic and international policies related to inorganic fertilizers are reviewed to inform supply chain and policy recommendations.

Main Findings

- In this study, the inorganic fertilizer supply chain is categorized into three main segments—raw material procurement, domestic production and distribution, and consumption and export markets—to establish a stable supply network.

- Using input-output analysis, the study distinguishes and examines the ripple effects of rising inorganic fertilizer raw material prices and the difficulties in securing supply on related industries. When international raw material prices increase, the fertilizer and nitrogen compound industries experience the largest price rises, followed by agricultural sectors that directly use inorganic fertilizers, including rice, cereals, vegetables, fruits, and floriculture. Processed agricultural product industries, such as milling, fruit and vegetable processing, and seasoning and food additive industries, also show significant price increases. Additionally, sectors that utilize both raw and processed agricultural products, such as the restaurant industry, are affected. The impact of difficulties in securing raw materials due to export restrictions is also analyzed. Results indicate that a one-unit decrease in imported mineral fertilizer raw materials leads to reductions in production of 0.305 units in fertilizer and nitrogen compounds, 0.246 in vegetables, 0.161 in general restaurants, 0.144 in rice, 0.123 in milled grains, and 0.092 in fruits.

- The international prices of key inorganic fertilizer raw materials—including urea, ammonia, phosphate rock, DAP, and potassium chloride—have shown a gradual increase over time, with price volatility rising in the 2020s compared to the 2000s. Raw material prices are strongly influenced by international political conditions, crude oil and agricultural commodity prices, and export restrictions or controls from major exporting countries. Urea and ammonia are also produced and exported by oil-producing countries, suggesting potential for diversification of import sources if difficulties arise in securing these materials.

In contrast, phosphate rock, DAP, and potassium chloride exhibit higher concentration in specific producing and exporting countries, making diversification relatively more challenging. However, phosphate rock from Tunisia and potassium chloride from Laos have comparatively lower export volumes relative to their reserves, indicating potential opportunities for future import source diversification from these countries.

- Regarding domestic raw material imports for fertilizer production, urea and ammonia appear to have diversified import sources, whereas DAP and potassium chloride remain concentrated due to significant regional differences in production and reserves, indicating limited diversification. Future policies should consider country- and region-specific export volumes and reserves to support diversification of key raw material import sources. Overall fertilizer production has decreased, but changes vary by fertilizer type. While conventional fertilizers and compound fertilizers show declining supply, the supply of CRF and functional fertilizers has increased, suggesting a need for development and support for these growing categories. Analysis of distribution and pricing systems reveals differences by fertilizer type. Conventional fertilizers are primarily supplied through NongHyup Economic Holdings and regional cooperatives, and prices are largely determined through these channels. In contrast, four-type compound fertilizers and micronutrients compound fertilizers are scarcely supplied via NongHyup, with inconsistencies in labeling of nutrient content and regional price variations. This may hinder farmers' ability to accurately assess fertilizer effectiveness and relative cost, highlighting the need for improvements in

relevant regulations and systems.

- Overall consumption of inorganic fertilizers, particularly nitrogen, phosphorus, and potassium, has been declining and is projected to decrease further due to reductions in cultivated area. However, survey results indicate that the use of CRF, four-type compound fertilizers, and micronutrients compound fertilizers is expected to increase. While total mineral fertilizer usage may decline, variations are anticipated across different fertilizer types. Farmers consider CRF effective when nutrient release timing is clearly indicated. They also emphasize the need for diversified micronutrients content and biodegradable coatings. Regarding four-type and micronutrients compound fertilizers, farmers perceive them as necessary to enhance crop yield and quality. Farmers typically obtain information on these fertilizers either independently or through NongHyup and local suppliers. They also recognize the importance of clear labeling of nutrient content, inclusion of diverse micronutrients, and training on proper application methods.

Policy Suggestions

- For the persistence of the inorganic fertilizer industry, a stable supply chain must be established through the following measures. First, raw materials must be secured in a stable and reliable manner. Second, the production and distribution stages need to be systematically improved. Third, inorganic fertilizers should be supplied in a way that reflects the demand of farmers as the end consumers. In other words, it is necessary to construct a supply chain that ensures the timely provision of fertilizers in appropriate

quantities and at reasonable prices according to farmers' needs. If the supply chain for inorganic fertilizers is established in a stable manner, it is expected that the sustainability of related industries, including fertilizer manufacturers and distribution actors, can also be secured.

- Measures to secure stable raw materials include (1) stockpiling key raw materials, (2) providing transport subsidies for public procurement, and (3) operating an early warning system. Among the materials to be stockpiled, DAP—which relies heavily on imports from China—would be a primary target. Following Japan's stockpiling policies for DAP and potassium chloride, storage costs should also be considered. To reduce dependence on short-distance imports from China and diversify supply sources, imports from regions with longer maritime transport, such as the Middle East, may be necessary. In this process, joint procurement of raw materials under Article 22 of the "Act on Stabilization of Supply Chains for Economic Security" could reduce transport costs and provide financial support. Additionally, given that most inorganic fertilizer raw materials are imported and thus vulnerable to international conditions and export controls by major suppliers, an early warning system is needed to ensure stable supply. Such a system can provide essential data to support stockpiling and diversification of import sources.

- Improvements in the production and distribution stages include (1) enhancing labeling of fertilizer components and content, (2) strengthening quality control, (3) revising regulations on CRF nutrient release rates, (4) supporting R&D for fertilizers with

increasing demand, and (5) fostering collaboration with regional agricultural promotion agencies. In four-type and micronutrients compound fertilizers, key nutrient contents are often not clearly indicated, creating information asymmetry between farmers and producers. To address this, all components and their concentrations should be clearly labeled on the product. With increasing diversity in nutrient content, quality management must also be strengthened. Survey results indicate that farmers require explicit information on nutrient release rates for CRF fertilizers. Currently, regulations only specify nitrogen release rates under the "Fertilizer Standards." Future standard for test should also cover key nutrients such as phosphorus and potassium and extend release periods beyond 24 hours to longer durations, such as up to 30 days. Considering supply trends and farmer surveys, demand for CRF, four-type, and micronutrients compound fertilizers is expected to rise, partly due to aging farmers. Support is needed for developing technologies related to CRF release rates and biodegradable coatings. Many four-type and micronutrients compound fertilizers are produced by relatively small-scale manufacturers with limited R&D and commercialization capacity. Collaboration with regional agricultural promotion agencies is therefore necessary to support R&D and commercialization. Additionally, such collaboration can help verify fertilizer efficacy and mitigate potential damage from over-application.

- Farmers were found to require education on the efficacy, potential damage, and proper use of four-type and micronutrients compound fertilizers. Accordingly, training on the application of newly supplied fertilizers should be provided through agricultural

technology centers. Surveys indicate that farmers typically rely on information from sales representatives at local cooperatives or suppliers when purchasing fertilizers, highlighting the need for training these personnel on fertilizer effectiveness, risks of over-application, and proper usage. Finally, temporary price compensation policies to mitigate the impact of sudden spikes in raw material prices should be maintained. Sharp increases in fertilizer prices raise production costs for farmers and threaten the sustainability of agriculture, which in turn affects the long-term stability of the mineral fertilizer industry. Therefore, such price support measures should remain in place until relevant legislation on essential agricultural materials, as proposed in the National Assembly, is enacted.

- To maintain and manage a stable mineral fertilizer supply chain, it is necessary to establish a dedicated coordination committee. This committee should include key stakeholders such as fertilizer manufacturers, cooperatives, suppliers, farmers, government representatives, and relevant experts. The committee would discuss raw material prices and availability, international developments, and domestic demand, while using indicators from the early warning system to ensure the supply chain is operated and maintained in a stable and responsive manner.

A Study on Strategies to Promote Exports of Companion Animals Related Industries

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Background and purpose

- The companion animal-related industry comprises a diverse set of industries, each at a different stage of development. Therefore, stimulating exports requires tailored strategies tailored to each sector. Therefore, this study analyzes the current status of the domestic and international companion animal-related industry, identifies challenges faced by exporters in each sector, and identifies the aspirations of companies not currently exporting. This analysis, in turn, proposes measures to boost exports in the companion animal-related industry.

- To this end, we first analyze the current status of domestic and foreign companion animal-related industries and export-related policies. Second, problems and difficulties are collected through surveys and case studies of companies in companion animal-related industries, and third, policies to promote exports of companion animal-related industries are presented in terms of establishing laws and systems, building infrastructure, and securing industrial competitiveness.

Research Methodology

- The companion animal-related industry can be broadly categorized into ① pet food, ② pet healthcare, ③ pet tech, ④ pet supplies, and ⑤ pet healthcare. In this study, the veterinary and insurance sectors and pet services within pet healthcare were excluded from the analysis due to their intangible nature as services, making them less relevant to exports. Therefore, this study limited its scope to ① pet food, ② pet supplies, ③ pet healthcare(devices), and ④ pet tech.

- We reviewed prior research and export policy data for each sub-sector of the companion animal-related industry, and analyzed statistical data to assess the current state of the industry. Furthermore, we selected major overseas pet food markets(the United States and Japan) and conducted an in-depth analysis of their export promotion policies and import-related systems. This analysis aimed to identify applicable policies for the overseas export of Korea's companion animal-related industry. In addition, to understand the export situation of companion animal-related

companies, a survey was conducted targeting exporting and non-exporting companies, and efforts were made to analyze in-depth factors restricting exports of companies in each sector through case studies.

Key Findings

▶ 〈Current Status of the Companion Animal Industry〉

- Among the companion animal-related industries, the global market trade volume of the pet food sector is in the order of Germany, Thailand, and the United States. Germany is the largest country in the import and export of pet food, and by exporting high-quality and premium products and importing mid- to low-end products, it is effectively utilizing the export strategy of premiumizing pet food in connection with the brand image. Thailand is mainly formed by consignment production of custom trademarks of multinational famous brands, so there is a limit to Korea's benchmarking in terms of industrial composition. The U.S. mandates the registration of pet food imported from the country and uses it as a non-tariff barrier to its market through facility registration, labeling compliance, and safety inspection procedures. In addition, the U.S. actively promotes compliance with the Food Export Guidelines of the American Feed Management Association(AAFCO), emphasizing the safety and quality of products.

- Although the pet product sector is expected to continue to increase due to the spread of companion culture and the increased importance of improving the welfare of companion animals, the

product is not highly technical difficulty due to the nature of the manufacturing industry and is relatively sensitive to product unit prices, so it is expected that imported products will have a higher market share than domestic products.

- Among pet healthcare products, the market for animal medicines is formed mainly on farm animals, and it is necessary to consider ways to secure product competitiveness in the mid to long term due to low market demand for domestic products. Since pet tech is an item that is expected to expand in the future, it is necessary to prepare a strategy to secure product competitiveness and induce exports through the production of products that can be differentiated in the general pet product market based on the competitiveness of Korea's IoT technology.

▶ 〈Export Promotion Policies by Country〉

- The United States is using MAP and FMD grants to increase consumer confidence in pet food through veterinary training support, collaboration with local rescue organizations, and consumer promotional campaigns. This, in turn, is fostering brand competitiveness by emphasizing education and promotion of the quality, safety, and nutrition of domestically produced products.

- Japan secured a legal basis for export-related policies through the "Agricultural, Forestry, and Fisheries Products Export Promotion Act," which took effect in April 2020. Japan is promoting the export competitiveness of agricultural, fishery, and food products by designating key export items, establishing infrastructure such

as facilities, certification, and logistics in key production areas, establishing export facilities through matching funds with industry organizations, expanding logistics infrastructure, and supporting certification and marketing costs.

- In Korea, export support programs for the companion animal industry are being implemented primarily through the Korea Agro-Fisheries & Food Trade Corporation(aT). However, while the current support program is closely related to the US MAP program, it is difficult to find any corresponding content related to the FMD's mid- to long-term program. Furthermore, to revitalize companion animal industry exports, the export-related provisions of the "Companion Animal Industry Promotion Act," currently pending legislation in the National Assembly, need to be specifically supplemented.

▶ 〈Export Status and Policy Demand in Korea〉

- Among pet-related companies, exporters are eager to expand their export markets to new markets. However, market information on these markets remains scarce, highlighting the need for more detailed market information, particularly for major exporters. Furthermore, they cited regulatory and certification issues, logistics and distribution challenges, difficulties securing local buyers, and difficulties establishing local marketing strategies as key challenges. Therefore, support measures focused on export practices are also needed.

- Pet-related businesses appear to have low awareness of the government's organizational structure and policies related to pet-related exports. This highlights the need for increased public awareness of government policies, regardless of company size or export activity. Furthermore, while many exporting companies are aware of the government's pet-related export support programs, their experience with support and benefits is relatively low. However, beneficiaries report a high level of satisfaction with the programs, indicating that the programs are highly effective.

Policy Recommendations

- Factors hindering the export activation of the companion animal-related industry were explored, and based on this, the basic policy directions for activating the export of the companion animal-related industry were divided into laws and systems, infrastructure construction, and securing industrial competitiveness.

- Regarding laws and regulations, supplementing the export-related provisions of the "Companion Animal Industry Support Act" and developing additional policies are necessary to secure a basis for supporting the revitalization of exports in the companion animal industry. First, the "Comprehensive Plan for the Promotion and Support of the Companion Animal Industry," which is stipulated in the existing proposal to be developed every five years, needs to be refined to specify the development of export roadmaps for each product category. Second, given the diverse nature of the companion animal industry, designation of industry associations, legal status, and funding arrangements for each product category

are necessary. Third, a fund to support export revitalization policies should be established through the institutionalization of a matching ratio between government and private funds. Fourth, a one-stop package for export administration should be established. Furthermore, the introduction of the Korea- Financed Foreign Market Promotion Program(K-FMDP) is essential to establish a foundation for mid- to long-term business support.

- It is necessary to strengthen the functions of the one-stop export support system in relation to the establishment of the infrastructure. The current support system needs to be expanded and reorganized to consist of: ① a diagnosis system by export stage, ② a database of quarantine and certification mapping by country, ③ a library of standard licensing data, ④ a module for simplifying export documents, ⑤ a community function of export councils, ⑥ overseas marketing and buyer matching, ⑦ export consulting and advisory reservation, ⑧ one-click support project application, ⑨ data-based policy analysis, etc. to enhance the convenience and cost reduction of export administration of overseas companies. At the same time, it is time to actively establish statistics for companion animal-related industries as it is difficult to secure an objective basis for establishing support policies.

- In terms of industrial competitiveness, the pet food sector has developed the “Pet Food Nutrition Standard,” and products that comply with this standard can request “complete food” labeling. This is expected to broaden the range of product choices for consumers, who have previously relied on US and European feed guidelines. Furthermore, this standard can be utilized as marketing

material for exports. Furthermore, some developing countries face a high risk of product imitation, making securing intellectual property rights essential. Simply relying on quality competitiveness alone will not be sufficient to compete with imitators, making patents and trademark protection essential. Therefore, there is a need to further strengthen support for companies seeking domestic quality system certification and overseas intellectual property rights acquisition.

Improvement Tasks for the Agri-Food Consumer Price Index

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Purpose of Research

- This study aims to provide foundational data that can be utilized for research and policy related to agricultural and food consumer prices by calculating a consumer price index for agricultural and food products that reflects household characteristics, conducting a survey on consumers' perceptions of agricultural and food prices, and analyzing the factors driving fluctuations in the agricultural and food price index. Based on these analyses, the study also seeks to propose improvement tasks for the agricultural and food consumer price index. The specific objectives are as follows. First, to construct an agri-food consumer price index reflecting household characteristics—such as income quintile,

elderly household status, and whether the household is non-working. Second, to analyze consumer perceptions and behaviors related to agri-food price inflation. This includes examining consumer perceptions of agri-food price increases, identifying how consumers respond behaviorally when prices rise, assessing consumers' perceptions of government price-stabilization policies, and analyzing how consumers view media reports related to agri-food prices. Third, to identify the determinants affecting the agri-food consumer price index and to estimate both the short-run and long-run effects of these factors using time-series data.

Research Method

- This study employs literature review, survey research, statistical data analysis, and expert consultations. The detailed methods are as follows. First, to construct household-specific agri-food consumer price indices, the Household Income and Expenditure Survey and Consumer Price Index data from Ministry of Data and Statistics were statistically analyzed. Second, an online consumer survey was conducted to examine perceptions of agri-food prices, and the results were statistically analyzed. Third, based on prior studies, relevant time-series data were analyzed to identify determinants affecting the agri-food consumer price index. Fourth, feedback from experts in research institutes, academia, and government agencies was incorporated into the study

Main Findings

- This study analyzes how agri-food price increases differently affect households depending on their characteristics. The results indicate that low-income households, elderly households, and non-working households spend a higher proportion of their food budget on rice and key ingredients used to prepare staple dishes such as kimchi—specifically non-glutinous rice, kimchi cabbage, and garlic—making them more vulnerable to price increases in these items. These households also allocate a relatively higher share of spending to processed marine products, including sea fish. In contrast, high-income, non-elderly, and working households spend a greater proportion of their food budget on meat products, resulting in different exposure to price shocks. For fruit, the share of expenditure on apples is higher among low-income households, elderly households, and non-working households than among high-income and working households. The household-specific agri-food price index reveals that during periods of inflation, the agri-food price index rises more rapidly for low-income, elderly, and non-working households.

- Consumers' perceived inflation rates were also compared with official data published by Statistics Korea. Across fresh agricultural products(excluding seafood), processed food, and dining-out categories, a large share of consumers believed that the actual price increase was higher than the official statistics. Among 28 major items, the products perceived to have experienced the highest price increases over the past three years, to be the most burdensome to purchase, and to require more active government price stabilization were largely consistent: apples, kimchi cabbage, beef, pork, eggs, fried chicken, and bread. When prices rise, the

most common consumer response across all categories was reducing the quantity purchased. Although awareness levels differed across specific government price stabilization programs—such as discount support programs, tariff-quota policies, and government reserve programs—many consumers expressed satisfaction with these policies. Regarding media coverage that emphasizes increases in agri-food prices, many consumers considered such reporting objective and useful, yet a significant portion also believed that it creates social anxiety and increases the government's cost of managing prices.

- An econometric analysis of time-series data was conducted to identify the short-term and long-term effects of various factors on agri-food consumer prices. In the long run, a 10% increase in agricultural product prices results in approximately a 7.56% increase in the food and non-alcoholic beverages consumer price index(CPI) and approximately a 9.00% increase in the agri-livestock-fishery CPI. A 10% increase in energy prices does not cause significant changes in the agri-livestock-fishery CPI but results in approximately a 1.76% increase in the food and non-alcoholic beverages CPI. In the short run, a 10% increase in agricultural product prices increases the food and non-alcoholic beverages CPI by approximately 1.48% to 1.61% and the agri-livestock-fishery CPI by approximately 1.58% to 2.27%. Additionally, when average wages in the food manufacturing sector rise by 10% in the short run, the agri-livestock-fishery CPI increases by approximately 1.44% to 1.45%.

Policy Suggestions

- Government policies related to agri-food prices need to evolve toward customized approaches targeting vulnerable groups such as low-income households. To achieve this, it is essential not only to establish early detection systems that monitor price volatility in items where vulnerable households have high expenditure shares but also to develop proactive mechanisms to respond before price increases occur. To support stable access to food for vulnerable households, policies should be designed to identify key items that require price stabilization for each household type and to provide targeted support such as vouchers or discount programs for those items. In addition, follow-up research is needed to quantitatively assess the welfare effects of such customized price policies and verify their effectiveness. Enhancing the government's capacity to manage agri-food inflation for vulnerable groups requires regular production of a household-specific agri-food price index—monthly or quarterly—that reflects household characteristics and provides necessary information for policy design.

- Consumers selected apples, kimchi cabbage, beef, pork, eggs, fried chicken, and bread as the items with high inflation, items that impose a financial burden, and items they want the government to prioritize in price stabilization. Therefore, more careful and intensive price management measures should be applied to these specific items. The survey also revealed that a considerable number of consumers believe media coverage emphasizing agri-food price increases contributes to social anxiety and increases the cost of government efforts to manage prices. This suggests the need for media to adopt more responsible

reporting practices to avoid amplifying unnecessary concerns.

- Achieving agri-food price stability ultimately requires structural improvements. Along with stabilizing agricultural product prices, policy support is needed to improve energy efficiency in the distribution and processing stages of the agri-food supply chain. While short-term policy measures aimed at mitigating temporary price fluctuations are important, policy focus should increasingly shift toward long-term stability. Because increases in labor costs in the food manufacturing industry are passed on to consumers in the form of higher agri-livestock-fishery prices in the short run, policy support should help agri-food businesses absorb wage-related cost shocks instead of transferring them directly to consumers.

Analysis and Development Strategies for the Agri-Food Supply Chain (Year 1 of 2)

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Background of Research

- The domestic and international environment surrounding Korea's agri-food supply chain is rapidly changing. The sector faces multiple risk factors—including climate change, unstable agricultural supply and increased price volatility, rising distribution costs, and difficulties in utilizing and sharing information.

- Therefore, it is necessary to analyze how effectively Korea's agri-food supply chain is currently functioning and identify which stages require improvement. This study focuses on establishing a "stable agri-food supply chain" and quantitatively diagnoses Korea's supply chain as a whole. Major bottlenecks at key stages are identified, and the study proposes corresponding improvement

tasks. The findings are expected to inform supply chain participants about the current status of Korea's agri-food supply chain while also serving as foundational evidence for policymakers in designing government policies and plans for supply chain improvement.

Method of Research

- To diagnose the performance of Korea's agri-food supply chain and derive improvement strategies, this research employed a variety of methodologies—including reviews of domestic and international literature, analysis of statistical data, in-depth interviews and surveys with supply chain participants and experts, SCOR model analysis, and case studies of international supply chains

- Expert interviews and literature reviews informed the selection of the research scope, methodological framework, specific influencing factors, and key performance indicators (KPIs). In-depth interviews and surveys with agri-food supply chain participants and experts were used to generate primary data for performance analysis and to identify participant-specific difficulties and perceptions of government policies.

- Using the SCOR model, the study quantitatively assessed the stability of Korea's agri-food supply chain. International case studies—focusing on the United States and Japan—were conducted to examine supply chain characteristics, policy responses for stability, and implications for Korea.

Research Results and Implications

- The central performance criterion in this study is the concept of a "stable agri-food supply chain." A stable agri-food supply chain refers to a state in which "agri-food products are sourced and supplied reliably despite risk factors, and consumers can readily purchase products of the desired quality."

- Focusing on the concept of a stable agri-food supply chain, this study examined the structural changes and key characteristics of Korea's agri-food supply chain. Major changes and their drivers were analyzed by categorizing the supply chain into the stages of production, distribution, and consumption. In addition, the study reviewed the main features of Korea's supply chain—including sharp fluctuations in agricultural product prices and instability of supply due to abnormal climate conditions, declining farm income and shortages of agricultural labor, diversification of distribution channels, and efforts to ensure food safety—and summarized the status of major participants such as producers, wholesale markets, and retailers.

- Based on survey results collected from farmers, food manufacturers, wholesale and retail firms, consumers, and experts, the study applied the Borich Needs Assessment and the Locus for Focus method to analyze perceptions of government policies. Farmers placed the highest priority on policies related to climate change response, management stability and income support, and agricultural disaster preparedness and risk management. Food manufacturers assigned high priority to policies supporting small and medium-sized food enterprises. Wholesale firms prioritized the modernization of public wholesale market facilities

and logistics subsidies, while retailers prioritized workforce capacity-building, quality and traceability management systems, and the establishment of cold-chain systems. Consumers rated agri-food price stabilization as the highest priority, while experts placed higher emphasis on price and supply stabilization, production-risk management, producer income stabilization, technological development, and digital transformation.

- To define a stable agri-food supply chain, the study adopted the concepts of availability and accessibility as essential components. Availability refers to "the conditions and capabilities enabling the sufficient supply of agricultural and food products of appropriate quantity and quality," while accessibility is defined as "the ability of consumers to readily access and purchase agri-food products of desired quality, supported by the system's capacity to ensure such access."

- Detailed factors that significantly influence availability and accessibility were selected. For availability, thirteen factors were identified: labor, capital and productivity, land, technology, production-risk management, producer management stability, supply volume management, food safety, foreign sourcing, producer information utilization, storage and reserves, distribution capacity and conditions, diversification of distribution channels.

- For accessibility, five detailed factors were selected: distribution capacity and conditions, diversification of distribution channels, product quality and food safety, price accessibility, and physical accessibility.

- Key performance indicators (KPIs) were then identified to represent each detailed factor. KPIs are crucial in diagnosing the agri-food supply chain using the SCOR framework because the results of the analysis depend heavily on the choice of indicators. In total, 30 KPIs were selected—24 representing the 13 availability factors and 6 representing the 5 accessibility factors.

- Using the SCOR model, the study quantitatively assessed the current state of Korea's agri-food supply chain. The analysis produced a stability score of 6.397, indicating that while the supply chain maintains a basic level of functionality, continuous management is required. In other words, "an assessment of improvements in the stability of the agri-food supply chain over the past 20 years, based on 30 KPIs, suggests that the system is closer to the level of smooth operation (8 points) than to the average (3 points)." Among the 30 KPIs, 12 indicators—including food manufacturing labor, online agri-food transactions, agricultural capital, local-level distribution capacity, pest and disease control, agricultural technology, farm scaling and specialization, share of transactions outside wholesale markets, crop insurance, food manufacturers' business performance, non-compliance rates, and contract farming—were designated green, reflecting stable improvements. Fifteen indicators—such as consumer trust in food safety, retail distribution capacity, land use, terms of trade for farms, distribution capacity in production regions, online wholesale market conditions, information utilization by farmers, agricultural labor, physical access for consumers, satisfaction with product quality, raw-material procurement by food manufacturers, inventory management,

information utilization by manufacturers, food price increases, and livestock-disease control—were classified as yellow, indicating a basic level of performance but a need for management. Three indicators—storage and reserves, capital capacity of food manufacturers, and diversification of import sources—were designated red, signaling deterioration and the need for improvement.

- To derive improvement strategies for Korea's agri-food supply chain, the study examined characteristics, major risk factors, and government response strategies in foreign supply chains. Based on the U.S. case, the study emphasized the need for: designing policies that integrate weekly data on prices, logistics, and climate using ERS-style real-time monitoring; establishing a long-term and sustainable model for agricultural price stabilization based on Price Loss Coverage (PLC) and Agricultural Risk Coverage (ARC); reviewing the adoption of Market Assistance Loan (MAL) programs; and examining the applicability of small-farm insurance programs such as Whole-Farm Revenue Protection (WFRP). From the Japanese case, the study highlighted the need to strengthen institutional support enabling wholesale markets and direct transactions to function complementarily, and to reinforce collaboration networks and information-sharing systems among producers, distributors, and retailers.

- Synthesizing findings from the analysis of Korea's supply chain characteristics and risk factors, SCOR-based quantitative diagnosis, international case studies, and stakeholder surveys, the study presented eight key improvement tasks for enhancing stability in

the agri-food supply chain.

- First, contract farming between agricultural producers and food manufacturers should be expanded. Contract farming reduces producers' uncertainty arising from price fluctuations and allows food manufacturers to secure raw materials more reliably. Since pre-contract stages may function as entry barriers, government support should be strengthened to facilitate cooperation between producers and manufacturers before formal contracts are concluded.

- Second, farmers' utilization of weather information must be improved. Survey results show that farmers rely most heavily on weather information for production decisions, yet the information lacks specificity and has low usability in the field. Although government-led systems such as the Agricultural Meteorological Disaster Early-Warning System have advanced, farmers still struggle to interpret weather information for concrete production decisions. Thus, a shift is needed from "information development" to "enhancing usability," along with a more timely provision of detailed weather and damage-prediction information.

- Third, R&D investment for small food manufacturers must be strengthened. Small food manufacturers tend to have low equity ratios due to limited capital structures, constrained access to external financing, and burdens related to facility improvements and equipment investments. These challenges weaken the stability of raw-material procurement, satisfaction with information availability, inventory management capabilities, and responsiveness to consumer needs. Improving equity ratios requires increasing

capital rather than merely reducing assets. Enhancing profitability through high-value product development, cost-reducing process improvements, and productivity gains via automation is essential, and such strategies require sustained R&D investment. Given limited private-sector capacity, government-led R&D support should be expanded.

- Fourth, private-sector capacity for storage and reserves must be strengthened. Storage and reserves play a crucial role in stabilizing prices during supply-demand imbalances and in securing emergency supply buffers. With government facilities facing shortages and increasing reliance on private warehouses, enhancing private storage capacity—particularly among producer organizations—is essential. A system in which the government compensates part of the losses arising from price differences between storage and release periods would incentivize storage and distribute risk. Over the long term, this approach would also improve data availability on storage volumes.

- Fifth, management of human and vehicle movement must be strengthened to prevent livestock diseases. The past three years have shown slow progress in controlling highly pathogenic avian influenza (HPAI). Given that contamination via human and vehicle movement is a major cause of outbreaks, stronger management of livestock-related facilities, stricter biosecurity standards for livestock-vehicle owners and drivers, and the imposition of biosecurity obligations on non-farm personnel entering farms are necessary.

- Sixth, a phased diversification of import sources is needed, especially for highly import-dependent items such as wheat, soybeans, and corn. Short-term diversification is difficult due to the private-sector-led import structure, trade barriers including tariffs, quarantine and hygiene standards, compatibility of imported varieties with domestic consumption, and trust-based relationships with existing suppliers. Thus, Korea must gradually conduct advance research on potential export countries and varieties and build institutional and legal frameworks that allow the government to play a stronger role in managing long-term import-source risks during crises such as global price surges or production declines in major exporting countries.

- Seventh, a structural response mechanism to price volatility should be established. Rather than relying on one-time, budget-intensive price stabilization programs, Korea should transition to sustainable policies that automatically compensate farmers for income losses due to price or yield declines without directly intervening in the market. Consumer-perceived inflation should also be considered. Prioritizing items like apples and cabbage—where both actual price increases and perceived inflation are high—would directly address consumer anxiety, strengthen trust that the government is addressing everyday price concerns, and contribute to lowering overall inflation.

- Eighth, a sustainable diagnostic system for the agri-food supply chain must be developed. The study proposes establishing the Korea Agri-food Supply Chain Index (KASCI) and conducting annual evaluations through a Supply Chain Diagnostics Committee.

This committee should regularly update required datasets, conduct surveys when necessary, and continuously revise or add KPIs in response to evolving supply chain conditions.

A Study on the Development of the Rural Regeneration Model Using the Living Labs Approach (Year 3 of 5)

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Purpose of Research

- This study is a five-year (2023-2027) research project aimed at developing and disseminating a sustainable rural regeneration model that addresses the structural decline of rural areas through a resident-led, data-based, and evidence-centric approach. Building on the conceptual and analytical framework established in the first year and the foundational model designed through an in-depth analysis of role models in the second year, the third-year study seeks to apply the theoretical model to actual field sites, evaluate its effectiveness, and propose it as a nationally

scalable policy alternative.

Research Method

- The experiences of national rural regeneration Role Models (RM) were systematized into units of role model actions (RMA) and compiled into a role model database (RMDB). From the RMDB dataset, core principles that were reproducible across regions, referred to as lessons learned, were derived by removing context-specific elements. These principles were then used to construct a standardized lesson learned inventory (LLI).

- These lessons were translated into concrete practices specifying actors, conditions, procedures, and performance management systems. These practices were subsequently demonstrated and applied at third-year replicator sites—Namyang-myeon in Cheongyang-gun and Juam-myeon in Suncheon-si—using a resident-led living lab approach. The effectiveness and implementation capacity of the rural regeneration model were assessed by comparing pre- and post-demonstration outcomes using key performance indicators (KPIs).

- The study also sought to improve model precision by redefining success and failure factors identified during the demonstration process as additional lessons and integrating them into the subsequent year's research. In addition, data accumulated in the RMDB and the LLI were used to develop an AI Navigator (chatbot) prototype to evaluate its potential functionality as a policy dissemination platform.

Main Findings

- It was found that rural regeneration role models develop through a sequential pattern: first, social capital is formed through the establishment of organizations and governance, which is subsequently reinforced by human and cultural capital; once these are established, natural capital, such as spaces and landscapes, is secured, ultimately leading to the creation of financial capital. This empirically demonstrates that building a "software" foundation, including resident organization and capacity, must precede "hardware" investments in physical infrastructure.

- An analysis of key leverage capital for rural regeneration confirmed that social capital (trust and cooperation within the community) and human capital (the presence of leaders and resident capacity) serve as catalysts for the expansion of other forms of capital.

- Through on-site demonstrations using a resident-led living lab approach, an actor and organization for integrated care projects were established in Namyang-myeon, Cheongyang-gun, and an implementation organization for the "kleingarten" business model was developed in Juam-myeon, Suncheon-si. This demonstrates that the rural regeneration model is effective in strengthening community capacity and establishing a foundation for self-sustaining development at the local level.

- By developing a "Rural Regeneration AI Navigator" prototype that provides customized consulting to on-the-ground actors based on data from the systematically constructed RMDB, the research outcomes were translated into a practical policy tool (policy proposal).

Policy Suggestions

- Policy support is needed in the initial stages of projects to build social and human capital, such as community organization and capacity building. Subsequently, a phased and customized support approach should be implemented, progressing toward physical investments, such as space creation and profit-generating projects.

- To activate "Learning by Doing" style living labs where residents diagnose local problems and find solutions through small-scale experiments, it is necessary to introduce a "Stage Zero" policy package that supports the early stages of idea generation and trust-building, while also providing flexible support for operational costs, such as activity fees.

- If the rural regeneration support platform developed in this study is expanded into an integrated, cross-ministerial policy support system, it can effectively link bottom-up resident initiatives with top-down government programs. It could also serve as critical infrastructure for breaking down interministerial silos and supporting efficient, data-driven policymaking.

- Through institutional linkages that utilize the rural regeneration model's diagnostic and evaluation tools as instruments for implementing the Rural Spatial Plan and Rural Agreement, it is possible to enhance on-the-ground execution and resident-perceived effectiveness.

Food Market Responses to Demographic Changes (Year 2 of 2)

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Purpose of Research

- This study aims to analyze the impacts of demographic changes on the food market and to propose strategic policy responses. In the first year (2024), the research focused on the implications of demographic change and related policy tasks from the perspective of food consumption, while in the second year (2025), it examined the effects of demographic change on the food market from the production perspective. To this end, the study reviewed the current and projected supply and demand of labor in the food industry under demographic changes, identified key challenges through an analysis of the food industry's workforce (manufacturing and foodservice sectors) and industry perception surveys, and

evaluated current labor policies and support programs. The findings from both years were integrated to suggest strategies for the food industry in the face of demographic shifts.

Research Method

- The study employed literature review, basic statistical analysis, firm-level surveys, collaborative research for econometric analysis, institutional and policy analysis, as well as expert interviews and advisory meetings. Based on literature and statistical analyses, the study identified the current status of the food industry workforce and, through surveys of firms, assessed their awareness of and responses to labor shortages driven by demographic change. Using employment projections from the Korea Employment Information Service, it examined future labor supply and demand trends in the food industry. Econometric analyzes estimated the elasticity of capital-labor substitution in the food manufacturing sector, comparing food manufacturing with other manufacturing industries and across sub-sectors within food manufacturing. In addition, policies and systems related to workforce management in food manufacturing and foodservice sectors were reviewed, and policy tasks were derived based on expert consultations and best-practice cases

Main Findings

- Prospects for the Impact of Demographic Change on the Food Industry

- Based on mid- to long-term labor market projections (Korea Employment Information Service), the population aged 15–64 is expected to decline by an annual average of 1.1% from 2023 to 2033, with a particularly sharp drop among core working-age groups (30–59). Employment in the restaurant sector is projected to decline by 1.3% annually, while employment in food manufacturing is expected to slightly increase until 2028 and then decrease by 0.5% per year from 2028 to 2033. Severe labor shortages are anticipated in occupations such as "cooking and food service" and "food processing machine operation." Conversely, employment in beverage manufacturing and non-alcoholic beverage service sectors is expected to remain stable or even increase.

- To analyze the capital-labor substitution elasticity in food manufacturing, two data sources–Value Search Corporate Panel Data and KODATA Corporate Panel Data–were utilized. Using Value Search data, the elasticity in food manufacturing increased from 0.022 (2014–2016) to 0.114 (2020–2023), though it remained lower than that of overall manufacturing (0.075→0.161). This suggests that substitution of labor with capital (automation or new technologies) is still limited in food manufacturing compared to other industries, yet the rising elasticity over time implies an increasing potential for automation and technological substitution.

- Labor in the Food Manufacturing Industry and Company Perceptions

- As of 2023, approximately 390,000 people were employed in food manufacturing, accounting for 9.5% of total manufacturing employment. The share of food manufacturing within total

manufacturing has been rising, yet its employment structure remains vulnerable, with a higher proportion of temporary and daily workers. Despite gradual improvement, the average hourly wage in food manufacturing remains only 73.7% of the manufacturing average (2024). The industry also exhibits higher occupational accident rates. Limited wage growth with tenure, insufficient capacity for workplace improvement among small and medium-sized regional firms, and weak working conditions deter young workers from entering the sector. Chronic labor shortages persist, particularly among production workers, while high physical demands limit the utilization of older workers. Administrative burdens and language barriers also hinder the replacement of domestic labor with foreign workers.

- Although sales and employment in food manufacturing have both increased, their correlation has weakened, indicating a need for continued labor input. The workforce structure—dominated by women and those aged 50 and older—remains fragile, requiring improved work environments and regional infrastructure to attract younger workers and to ease constraints on employing older and foreign workers.

- Labor in the Foodservice Industry and Company Perceptions

- In 2023, the foodservice industry employed approximately 2.12 million workers, representing 8.3% of total employment. While the workforce structure has gradually improved, it remains vulnerable, characterized by a high proportion of female, elderly, and low-educated workers, and by extensive use of temporary rather than regular employees. Average wages are only 58% of

the overall industry average, and shortages are particularly severe among “hall service and counter staff.” The sector struggles to secure workers due to long working hours, low pay, unstable employment, and low social recognition. Wage growth with tenure is minimal, discouraging long-term employment and resulting in high turnover rates.

- Many foodservice businesses rely on short-term youth workers or unpaid family members to cope with labor shortages. However, continued demographic aging, youth population decline, and negative perceptions of service jobs are likely to exacerbate future workforce shortages. Although the pilot program under the Employment Permit System (EPS) has allowed employment of foreign workers in the foodservice sector, its effectiveness remains limited due to administrative complexity and communication ability of foreign workers. Digital technologies–such as kiosks, automated cooking systems, and serving robots–are being introduced, yet small business scale, cost burdens, and space limitations constrain broader adoption. Nevertheless, such technologies have the potential to reduce labor intensity and ease workforce shortages in the future.

Evaluation of Employment Policies for Food Industry

- South Korea, with its high proportion of elderly citizens, faces concerns over declining labor participation, working hours, and productivity due to demographic shifts. As the retirement of the aging baby-boomer generation (around 2028) is expected to trigger a sharp reduction in labor supply, the government has

introduced a range of measures to promote economic participation among older workers, encourage women's employment, activate youth hiring, and utilize foreign labor. These include employment subsidies for hiring older or young workers, and work–family balance support programs. The Ministry of Agriculture, Food and Rural Affairs (MAFRA) operates several food-sector-specific programs such as the Food and Dining Youth Internship, Agri-Food Venture Start-up Internship, and Korean Cuisine and Food Service Promotion projects that foster highly skilled culinary professionals. In addition, foreign worker programs include the Employment Permit System, restaurant work permits for holders of the Visit Employment Visa, and projects supporting small- and medium-sized enterprises (SMEs) in attracting foreign specialists.

- Various policy efforts are also underway to promote capital investment, automation, and the adoption of new technologies. These include developing AI-based automation technologies, supporting related R&D, advancing food-tech policy, and implementing pilot projects for food-service robots. In particular, MAFRA has focused on building institutional and infrastructural foundations for the food-tech industry. Workforce training and information-sharing programs are also in place—such as food-tech contract departments, commercialization of food-service and food-tech technologies, and the development of new models for traditional foods—covering instructor fees, training costs, and operating expenses. Other initiatives include training programs for food industry professionals, functional food experts, and short-term job-matching support for firms located in the National Food Cluster. The Ministry of Employment and Labor seeks to alleviate

information mismatches through online employment platforms, while some local governments run programs for online marketing training, job-matching for restaurant businesses, support for closing or soon-to-close micro-enterprises, and assistance for platform workers.

- Survey results show that food manufacturing firms perceive foreign labor policies as the most effective, followed by youth and senior employment policies. However, awareness and utilization of automation and smart-technology support remain low. In contrast, foodservice firms show higher recognition and positive evaluation of digital transformation policies, reflecting the government's recent efforts to promote smart technologies among small businesses.

Policy Suggestions

- The food industry continues to grow, with demand rising particularly in the processed-food and dining-out sectors. This industrial expansion will inevitably increase labor demand; however, given Korea's declining population, labor shortages in the food sector are expected to persist. In response, this study proposes three strategic directions: (1) workforce-securing strategy, (2) automation and food-robot adoption strategy, and (3) workforce development, education advancement, and information-provision strategy.

- First, the workforce securing strategy emphasizes improving job perceptions, working conditions, and the overall employment environment in the food industry to attract and retain domestic

workers. Improving wages and working conditions requires structural reforms within the industry and a shift in employers' awareness of workplace conditions. For regional food companies, collaborative programs linking government and local government support—such as commuting assistance for workers and safety facilities—should be expanded. It is also essential to improve food firms' access to existing labor policies that promote employment of older adults, women, and youth, as many small firms remain unfamiliar with such schemes. A dedicated labor consultation and support system should be established to provide guidance on labor regulations and workforce programs. Additionally, institutional reforms are needed to improve the foreign labor system—particularly the Employment Permit System for foodservice sector and skilled foreign worker programs for food manufacturing. Developing sector-specific labor statistics and providing food- and service-oriented training for foreign employees will also be important.

- Second, the automation and food robotics strategy seeks to enhance the work environment and reduce labor dependency through technological innovation. This includes expanding smart factory adoption in food manufacturing, promoting smart technology and food robot use in the food service sector, and developing standardized models for food robot testing and application. Policy efforts should focus on upgrading existing programs, training professionals in smart manufacturing, and incorporating artificial intelligence (AI) into smart factory systems tailored to the food industry.

- Finally, the human resource development and education advancement strategy emphasizes addressing labor shortages and enhancing productivity through technology adoption. This involves developing retraining programs for incumbent workers to adapt to new technologies or alternative tasks, establishing job-matching platforms to connect skilled workers with appropriate positions, and promoting these services to ensure broad participation. For export-oriented firms, the study also suggests developing processed food clusters to foster skilled labor and improve efficiency, while promoting the export of integrated packages combining food products, manchinery, and food-tech innovations.

Forecasting Agricultural Labor Supply and Demand in Response to Agricultural Environmental Change

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Purpose of Research

- This study aims to analyze the agricultural labor supply-demand dynamics in response to changing agricultural environments in Korea. Specifically, it seeks to develop a model to forecast agricultural labor supply and demand over the long term and evaluate the impact of various environmental, economic, and policy factors.

Research Method

- This study uses a comprehensive approach that includes literature review, policy document analysis, and statistical examination of agricultural labor supply and demand changes. A system dynamics modeling technique was employed to create causal maps, flow diagrams, and optimization equations for the labor supply-demand model. The model was validated, and future scenarios were developed to forecast agricultural labor needs under various conditions.

Main Findings

- Agricultural Environmental Trends: Over the period from 2000 to 2023, the average temperature in South Korea rose by approximately 1.5°C. The trend in solar radiation and sunshine duration has been increasing, and there has been a long-term rise in mechanization rates, especially for rice and field crops. Moreover, rural population dynamics show an increase in the proportion of individuals aged 65 and older, alongside growing foreign labor dependency in agriculture.

- Agricultural Labor Supply and Demand: The total demand for agricultural labor(measured in AWU) decreased by 46.8% from 1,278.7 thousand in 2000 to 680.9 thousand in 2023. This decrease was particularly driven by reductions in demand for rice, spices, and root vegetables. Conversely, demand for vegetables, fruits, and livestock increased. The agricultural labor supply also decreased faster than demand, with a 55% drop in domestic labor supply over the same period, exacerbating the aging of the agricultural workforce. Employment in foreign labor

increased as domestic labor supply dwindled.

- Labor Supply-Demand Model: The developed model demonstrated that agricultural labor demand and supply can be predicted with high accuracy(MAPE < 5%). It highlighted the significant roles of wage increases, mechanization, and climate factors in influencing labor hours. While wage increases led to reductions in labor input, mechanization helped to reduce work hours across all agricultural sectors.

- Future Labor Supply-Demand Scenarios: Three scenarios(Base, Favorable, Unfavorable) were tested. The base scenario showed that supply decreases faster than demand, leading to a growing labor shortage. The favorable scenario displayed a slower supply decrease, while the unfavorable scenario showed rapid declines in labor supply, especially among younger workers.

Policy Suggestions

- Policy directions to stabilize agricultural labor supply include: setting explicit domestic labor self-sufficiency targets and managing minimum domestic shares by crop, season and employment type; accelerating labor-saving mechanization and small, modular smart-farming/robotics, linked with expanded outsourcing and contract-farming services that bundle machinery, work execution and skilled operators; building a coherent skilled-labor strategy with skill-linked wage ladders, continuous training, pathways for high-caliber entrants, and specialized agricultural job-matching platforms; establishing a national

digital labor platform for real-time matching and advance allocation of workers, transport and housing; upgrading foreign worker schemes so that seasonal and permit-based migration functions as a flexible but clearly supplementary buffer under staged, rights-based management; strengthening farm profitability through price and income stabilization, cost-sharing, insurance and disaster compensation to support stable family and regular employment; and enhancing climate- and disaster-risk resilience via early warning systems, spatio-temporal diversification of workloads, and flexible labor allocation rules.

Effects of Agricultural Income Stabilization Policies and Improvement Tasks (Year 1 of 2)

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Purpose of Research

- Since the 2000s, Korean agriculture has undergone structural changes characterized by a rapid decrease and aging of the farming population, which have been pointed out as major factors hindering the sustainability of the agricultural sector. In a situation where the inflow of new farmers has stagnated, the decline and aging of the farming population lead to a weakening of the sustainability of Korean agriculture, and underlying this is the instability of income in the agricultural sector.

- Measures to stabilize farm income can largely be divided into policies aimed at increasing income and policies designed to reduce income volatility. Among the agricultural income

stabilization measures currently being implemented by the government, these two pillars are broadly represented by agricultural disaster insurance, which mitigates income volatility, and the public direct payment scheme, through which the government directly pays farm households to raise their income levels.

- Therefore, in order to strengthen the stability of agricultural income at present, it is necessary to measure the policy effects of programs that reduce income volatility and those that raise income levels, diagnose existing problems, and develop appropriate improvements. Before conducting such analyses, it is essential to examine the factors that determine the level of agricultural income, the elements that cause its volatility, and the characteristics of farm households.

- Although some studies have partially measured the effects of income-stabilization policies, comprehensive and systematic analyses of the effectiveness of agricultural income stabilization measures remain insufficient. As a result, it is unclear which income-stabilization policies should be prioritized and implemented in practice, and there are also limitations in deriving improvement measures to supplement the shortcomings of existing income-stabilization policies.

- The purpose of this study is to conduct a comprehensive analysis of the income-enhancing effects and income-volatility-mitigating effects of the various income-stabilization policies currently being implemented by the government, and to derive their policy implications.

- To this end, the study aims to evaluate policy effects, identify problems, and propose improvement tasks by conducting both a macro-level analysis covering the overall agricultural management entities over two years and a micro-level analysis that reflects the characteristics of different types of farm businesses. In the first year, the study analyzes the policy effects, identifies issues, and proposes improvement measures for income-volatility-mitigation policies, including crop disaster insurance, from the perspective of reducing income volatility. In the second year, the study seeks to analyze the policy effects of income-enhancement policies—such as the public direct payment scheme—identify their problems, and propose improvement measures.

Research Method

- As the main research methods, literature review, econometric analysis, partial-equilibrium dynamic optimization analysis, and surveys were conducted, and based on these, improvement measures were proposed.

- The literature review was used to examine previous studies and international cases related to existing agricultural income-volatility mitigation policies, while the descriptive statistical analysis employed the Farm Household Economy Survey to descriptively analyze trends in gross farm income, farm operating expenses, and farm income.

- The empirical analysis using econometric models specifically employed an IV model, an SFA model, and a CVM model based

on survey data to identify the performance and limitations of agricultural disaster insurance and to estimate its social value. In addition, scenario analyses were conducted using partial-equilibrium dynamic optimization analysis to examine the impact of disaster insurance on the stability of agricultural production.

- Lastly, a survey of farm households was conducted to identify the risk factors contributing to fluctuations in agricultural income.

Main Findings

- According to the survey on perceptions of agricultural income, it was confirmed that the instability of farm income has intensified significantly and has become persistent. Given that stable agricultural income underpins the sustainability of agriculture and provides the foundation for encouraging agricultural investment, this result implies a strong policy demand for measures that enhance the stability of farm management. A noteworthy finding from the survey on farmers' perceptions of income risk factors is that rice farmers identified changes in government policies as one of the main causes of declining agricultural income. This suggests that agricultural policies have lacked consistency and have changed irregularly, leading to very low levels of trust among farmers toward such policies. Therefore, for government policies to achieve successful outcomes, it is necessary for the government to send consistent policy signals to the market so that farmers can gain confidence in the continuity of policy direction, thereby encouraging their voluntary participation.

- To analyze the performance of policies aimed at reducing agricultural income volatility, this study conducted four types of econometric analyses.

- First, an analysis of the impact of agricultural disaster insurance on the volatility of gross farm income revealed that agricultural disaster insurance plays a positive role in stabilizing farm management by reducing the coefficient of variation of gross farm income. This analysis empirically demonstrates that management stability increases in proportion to the number of years of insurance enrollment. Therefore, it can be seen that actively expanding policy-based insurance is a desirable direction for the government to pursue in order to achieve the policy goal of stabilizing farm management.

- Second, an analysis of the impact of agricultural disaster insurance on productivity and technical efficiency found that agricultural disaster insurance shows a mixture of positive and negative effects on fruit farms' productivity and technical efficiency. On the positive side, agricultural disaster insurance was shown to enhance management stability and reduce income volatility for farm households. However, on the negative side, there appeared to be potential increases in inefficiency due to moral hazard, such as reductions in certain input factors after enrolling in insurance.

- Third, an analysis focusing on garlic and onions was conducted to assess the contribution of agricultural disaster insurance to production stability, and a scenario analysis was performed using a partial-equilibrium supply-demand model that assumed

a situation in which agricultural disaster insurance had not been introduced. The results showed that if insurance is introduced for only one of the two crops, the substitution relationship between them may lead to a contraction of the production base for both crops and a heightened instability in market prices. Therefore, in the case of crops with production substitution relationships, the findings suggest that agricultural disaster insurance must be introduced for both crops in order to maintain stable production and stabilize market prices.

- Fourth, the social value assessment of policies aimed at reducing agricultural income volatility estimated that the social value of the functions provided by agricultural disaster insurance amounts to approximately 34,000 KRW per household per year, with total annual benefits estimated at about 753.5 billion KRW. This empirically demonstrates that income-volatility-mitigation policies for farm enterprises possess policy value that extends beyond simple support for farmers and generates benefits for society as a whole. In addition, the analysis of heterogeneity in consumer valuation indicated that improving policy awareness and providing information are key factors that enhance policy value assessments.

- A review of income-volatility-mitigation policies in countries such as the United States, Canada, and the EU shows that all of them pursue consistent agricultural income-stabilization policies over the medium to long term and have established multi-layered, complementary farm management safety nets. Therefore, farmers in these countries are able to optimize their decision-making because government policies operate within a predictable range.

Policy Suggestions

- All agricultural policies must be implemented to maintain the sustainability of agriculture, and policies aimed at reducing agricultural income volatility are no exception. Such policies should not merely function to compensate farmers for temporary income declines; rather, they should be designed to enhance the long-term growth potential of agriculture by enabling farmers to anticipate and absorb the risks inherent in agricultural management.

- Therefore, policies aimed at reducing agricultural income volatility must be pursued not only in the direction of providing ex post compensation but also in the direction of strengthening ex ante risk management. To achieve this, the policies must be financially sustainable, and consistent policy implementation is critically important. Only then can improvements in government policy credibility, the creation of a predictable management environment, enhanced risk-management capacity for farmers, and greater efficiency in market functions be achieved simultaneously.

- Based on the above discussion, the following specific policy tasks for reducing agricultural income volatility are proposed: ① Establishing a comprehensive policy consistency, ② Building a robust management safety-net system covering a wide range of commodities, ③ Implementing customized measures that reflect the characteristics of agricultural enterprises, ④ Supporting the enhancement of farmers' response capabilities, ⑤ Preparing comprehensive measures to reduce farm production costs, ⑥ Fostering Enabling Conditions and Other Improvement Tasks

(e.g., expanding eligible items considering substitution relationships, linking agricultural-related data, and strengthening policy communication).

Strategies for K-Food+ Export Expansion (Year 2 of 2)

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Purpose of Research

- This study aims to provide a comprehensive analysis of the competitiveness of eight K-Food+ industries—seeds, agricultural machinery, smart farms, pesticides, fertilizers, veterinary pharmaceuticals, pet food, and agri-food—and to examine the interlinkages among them. Building on this analysis, it proposes an integrated export expansion strategy and roadmap for the overall K-Food+ sector. The first-year research focused primarily on the upstream and downstream industries (agricultural machinery, pesticides, fertilizers, and veterinary pharmaceuticals), examining their export performance, current conditions, and economic ripple effects. The second-year research expanded the scope to include seeds, smart farms, pet food, and agri-food, with the objective of identifying the structural characteristics

and policy synergies of the entire K-Food+ industrial ecosystem and developing export strategies and a roadmap based on inter-industry linkages.

Research Method

- This study employed the following research methods to analyze the current status and competitiveness of the K-Food+ industries. First, an industry- and product-level classification system was developed based on the 6-digit Harmonized System (HS) code, and its validity was verified through expert consultation. The United Nations (UN) Food and Agriculture Association (FAO) item-based classification system was applied to the agri-food products. Second, export and import data by country and product were collected using statistics from the Korea International Trade Association, UN Comtrade, and FAO. Using the Boston Consulting Group (BCG) matrix, this study analyzed promising export markets and items, as well as continent-level market entry strategies. Third, an input–output analysis was conducted to examine backward and forward linkages, production and value-added effects, and key drivers of industrial growth. Fourth, indicators for evaluating global competitiveness and domestic export capacity were developed through expert consultations, and industry-specific priorities were derived using the Analytic Hierarchy Process (AHP). Finally, additional analyses—, including the status and impact of non-tariff measures—such as Technical Barriers to Trade (TBT) and Sanitary and Phytosanitary (SPS) measures by industry—and assessments of smart agriculture markets in Vietnam, Myanmar, and Indonesia, were supplemented

through collaborative research.

Main Findings

- The domestic seed industry is characterized by a structure in which a small number of large enterprises account for most vegetable seed exports. Whereas, small- and medium-sized enterprises (SMEs) possess technological capacity but face difficulties in securing global competitiveness because of insufficient research infrastructure and specialized human resources for new variety development. Major export items such as chili pepper, tomato, and cabbage seeds are competitive in terms of quality; however, heavy reliance on overseas seed production increases production costs and weakens price competitiveness vis-à-vis seeds from emerging economies. In particular, approximately 90 percent of Korean seeds are produced abroad and reimported, raising logistics and management costs, and constraining export expansion. Simultaneously, administrative delays caused by non-tariff barriers further increase the burden on firms. Addressing these structural challenges requires not only the establishment of stable overseas production bases led by the government but also a shift toward quality-oriented competitiveness through the development of new varieties differentiated from those of competing countries. However, given the long time horizons and high costs inherent to the seed industry, current levels of large-scale public R&D investment and sustained research programs remain insufficient to secure a robust, long-term research capacity. While exports are currently concentrated in the United States and a few Asian countries, large-population markets such as China, India, and

Indonesia, are emerging as promising new markets because of the growing demand for climate-resilient varieties and high trust in Korean seeds. Overall, the domestic seed industry has considerable potential in terms of technology and quality. However, insufficient R&D, complex foreign certification and quarantine procedures, and the high costs of overseas production continue to constrain growth, underscoring the need for long-term, industry-wide development policies. If these constraints are addressed, the sector could evolve beyond an agricultural input industry to become a technology- exporting industry.

- Korea's smart farm industry has advanced rapidly in terms of technological capability, yet its export base and industrial ecosystem remain at an early stage of development. Large firms currently dominate the market for facility-type smart farm equipment, while SMEs, despite having strong technological capacity, face structural constraints related to export infrastructure, certification, and on-site demonstration in overseas markets. As smart farming is a high-cost, high-technology sector that integrates Information and Communication Technology (ICT), the burden on SMEs is particularly significant. Currently, exports are concentrated in a limited number of markets such as Taiwan, the United States, and Japan, rendering the industry vulnerable to external shocks. Diversification of export destinations therefore requires region-specific strategies, including water-saving solutions for the Middle East; Environmental, Social, and Governance (ESG) and energy technologies for Europe; and Official Development Assistance (ODA)-linked cooperation models for Africa. In addition, gaps in the HS code system hinder accurate assessment of industrial

realities and constrain tailored government support, indicating the need for system-wide improvements. Although Korean smart farm technologies and product quality in Korea are highly competitive, overall price competitiveness is constrained by high costs, including those related to certification, demonstration, and logistics. Overseas certification procedures are time-consuming and costly, especially for SMEs, and R&D investment tends to focus on short-term technology upgrades rather than long-term-large-scale innovation. There is a clear need to introduce major technology development programs in high value-added areas such as climate-smart technologies, energy control systems, and data platforms. Following technological development, it is essential to establish a package-type support system that links R&D, demonstration, certification, and commercialization, alongside international cooperation frameworks to address non-tariff barriers. As illustrated in the Netherlands, the establishment of an ecosystem based on cooperation among industry, academia, and government can generate synergies across technology development, commercialization, and human resource training. For export expansion, short-term support limited to trade fairs and marketing is insufficient. Given the long lead times required to conclude contracts, robust post-fair follow -up, training of after-sales service personnel, and joint after-sales service systems are required. In summary, while Korea's smart farm industry possesses strong technological capacity, weaknesses in export infrastructure, regulatory frameworks, R&D, and financial support highlight the need for a mid- to long-term strategy for ecosystem development. Such a strategy could foster the transformation of smart farming into an export-oriented industry,

and simultaneously strengthen the competitiveness of domestic agriculture.

- The domestic pet food industry is growing rapidly, driven by an increase in companion animal ownership and the spread of pet humanization. Large- and medium-sized enterprises are leading industrial expansion, while SMEs are focusing primarily on Original Equipment Manufacturer (OEM) and Original Design Manufacturer (ODM) production. The number of manufacturers and total production value continue to rise, yet the overall industrial ecosystem has not fully matured. Exports have increased sharply in recent years, concentrating on Asian markets such as Japan, Taiwan, Thailand, and Vietnam, while Indonesia, India, and New Zealand are emerging as promising new destinations. However, this regional concentration renders exports vulnerable to external risks, underscoring the need for market diversification. Korean pet food is generally regarded as technologically advanced and of high quality; however, its strong dependence on imported raw materials and high-cost industrial structure reduces its price competitiveness. The burden of overseas certification, quarantine, and logistics costs, together with import restrictions on certain ingredients arising from the Control of Livestock and Fish Feed Act and related regulations, constrain product diversification and export expansion. In addition, the prevalence of small-scale enterprises, lack of export-specialized personnel, and difficulties in responding to heterogeneous regulations across countries weaken the industry's overall competitiveness. To expand exports, it is essential to improve quarantine systems for raw material sourcing, foster international cooperation and standardization,

and diversify markets beyond Asia. Equally important are technological innovations focused on functional and premium products, strengthening a long-term R&D ecosystem, training export specialists, and facilitating capability-building program enterprises. Taken together, the domestic pet food industry has substantial growth potential; however, addressing imbalances in regulatory frameworks, infrastructure, and market structure is essential. Institutional support from the government and efforts to enhance SME competitiveness are critical for ensuring sustainable growth in global markets.

- Korea's agri-food exports have grown steadily over the past five years, and the export structure has shifted toward a greater share of processed foods, indicating a structural transition in export items. While exports remain heavily concentrated in major markets such as the United States, China, and Japan, the global spread of Korean cultural content (K-culture) suggests strong prospects for the diversification of export destinations. The agri-food sector has substantial potential for product diversification, and there is a need to maintain a processed food-centered strategy while actively leveraging the growth potential of fresh products to broaden the export basket. Simultaneously, export strategies should reflect global demand structures and country-specific characteristics, enabling the concurrent pursuit of core product concentration, emerging product growth, low-growth product management, and upgrading of potentially mature items. Product diversification should be used as a strategic framework within which export strategies are tailored and implemented according to market characteristics. The result of a survey of exporting

firms revealed marked differences in export performance across companies; however, agri-food exporters face difficulties in securing price and quality competitiveness. Additional challenges include non-tariff barriers, high certification costs, and inefficiencies in access to information. Consequently, policy support is needed to enhance firms' market responsiveness and to establish support systems that allow differentiated approaches according to the characteristics of each market. Government-led initiatives such as package programs that cover exhibitions, contracting, distribution, and follow-up support, as well as real-time information platforms on export-related non-tariff barriers, will be required to directly address the constraints faced by exporting enterprises.

- The K-Food+ export strategy seeks to promote the export industrialization of an integrated complex of industries, including seeds, smart farms, and pet food, in addition to agri-food products. Its overarching objectives are to strengthen responses to external risks, alleviate export-related difficulties, reinforce competitiveness, and advance strategies for market diversification and upgrading. On this basis, domestic support policies are being implemented by industry, complemented by an analysis of overseas cases, to derive policy lessons for export promotion. For the seed industry, the Third Five-Year Plan for Seed Industry Development is being implemented to foster a high-value-added seed export industry through enhanced R&D capacity, infrastructure development, and firm-specific support. Japan's support for the introduction of new vegetable varieties in Asian countries and the Netherlands' Seed Valley Cluster are being presented as key

international reference cases. In the smart-farm sector, the First Basic Plan for Smart Agriculture Development aims to systematically strengthen production bases, human resources, R&D, and data infrastructure. In addition, international experiences such as the Netherlands' Food Valley and Japan's smart agriculture packages highlight the importance of technology demonstration and public–private cooperation in ecosystem building. In the pet food sector, companion animal industry development measures focus on improving classification systems and labelling standards; as well as strengthening raw material and production bases, while supporting firms with overseas certification, intellectual property protection, local registration, and quarantine procedures. The United States Food and Drug Administration's eCATS system, which provides a robust foundation for certification and authenticity verification, offers a representative model to reduce the certification burden on domestic exporters. In the agri-food sector, initiatives such as market and trade information provision through the Korea Agricultural Trade Information (KATI) platform, export product development, expansion of joint logistics centers and cold chains, overseas certification support, participation in international trade fairs, and online marketing are reinforcing the export base across the entire value chain from production to logistics. International cases, such as Japan's Global Farmers/Fisherman/Foresters/Food Manufacturers Project (GFP); the United States' Market Access Program (MAP), Export Credit Guarantee Program (GSM-102), Emerging Markets Program (EMP), and Technical Assistance for Specialty Crops (TASC) program; and the European Union's promotion policy, provide multi-layered models that combine support for distribution, financial guarantees,

marketing, and non-tariff barrier responses. Overall, strengthening K-Food+ export competitiveness requires building cluster-and research- cooperation ecosystems for seeds; promoting private sector–driven upgrading in smart farms, improving certification and traceability systems for pet food; and reinforcing infrastructure, market diversification, and national branding strategies in the agri-food sector.

- Within the K-Food+ industries, primary agricultural and livestock products are largely consumed directly as final goods and exhibit relatively low use as intermediate inputs for other sectors. In contrast, food and beverage products are characterized by a high share of final consumption and by significant use as intermediate inputs. Excluding feed, the share of agricultural inputs used as intermediate inputs in other industries is relatively higher than that directly consumed as final goods. Industries with a high share of inputs from or to other sectors can be regarded as having strong interindustry linkages. An increase in exports in these sectors is likely to have relatively larger spillover effects on overall demand and growth in the broader economy. Sectors identified as having relatively strong linkages include seeds, agricultural machinery, smart farming, processed grains, fruit and vegetable products, and beverages; whereas, fresh agricultural products, feed, pet food, and fertilizers display weaker linkages. If interindustry linkages can be strengthened, a given increase in exports will have a larger impact on aggregate economic growth. An analysis of growth drivers by industry indicates that export expansion has had a positive effect on the growth of both agricultural input and agri-food industries

(agricultural and livestock products plus food and beverages). In particular, within the agri-food sector, export growth in processed foods has contributed more to output growth than that of fresh products. Within agricultural input industries, exports of veterinary medicines and medical devices, agricultural machinery, smart farm equipment, fertilizers, and pesticides have made substantial contributions to industrial growth.

- The export competitiveness of K-Food+ industries must be assessed by jointly considering factors such as performance in overseas markets, potential for international expansion, domestic industry size, and export capacity. To this end, this study evaluates sectoral export competitiveness using two dimensions—global market competitiveness and domestic export capability—and constructs five quantitative indicators for each. To ensure the objectivity of the quantitative indicators, expert survey results were used as weights, and the resulting index was compared with qualitative assessments of sectoral importance based on expert perceptions. The quantitative evaluation found that, in terms of global market competitiveness, smart farming ranks highest, followed by pesticides, veterinary medicines, and agricultural machinery. In terms of domestic export capability, agri-food products ranked the highest, followed by pet food, fertilizers, and veterinary medicines. Combining these results, the overall export competitiveness index ranks smart farming first, followed by veterinary medicines, pesticides, agri-food products, and agricultural machinery. In contrast, expert assessments of sectoral importance ranked agri-food products highest, followed by seeds, smart farming, and agricultural machinery, indicating some

divergence between quantitative and qualitative evaluations. Quantitative assessments capture the current level of industrial competitiveness, whereas qualitative evaluations reflect a broader set of factors, including perceived industrial importance, social value, and future potential. Recognizing these differences, this study derives policy directions and implications by considering both quantitative indicators and qualitative expert judgments.

- By integrating the findings from both the first- and second-year studies, this study presents strategies for enhancing export competitiveness and strengthening inter-industry linkages within the K-Food+ sector. K-Food+ is a composite industrial cluster that encompasses consumer goods, technological goods, and input industries—including agri-food, pet food, seeds, and smart farms—indicating potential for synergy not only through strengthening individual industries, but also through integrated value-chain linkages. The veterinary pharmaceutical industry possesses strong technological capabilities; however, its export expansion potential remains limited, suggesting the need for strategies centered on high value-added product development and market diversification. Agri-food, pet food, and fertilizers demonstrate strong domestic capabilities, but weaker global competitiveness, requiring strategies focused on branding, localization, and technological innovation. The seed and agricultural machinery industries have moderate technological competitiveness, but lack industrial foundations and export capacity, highlighting the need for strategies to reinforce R&D, commercialization, and maintenance systems. Pesticides and smart farms exhibit global competitiveness but have weak domestic foundations and supply capacity, making it

necessary to build strategies around supply-chain stability, technological internalization, and post-management systems. These results indicate that each industry requires differentiated strategies, and that complementary measures must be established at each stage of the value chain—from technology and production to processing and branding.

- Based on quantitative and qualitative analyses of each industry, the following competitiveness enhancement strategies were derived:
  - Seeds: Promote commercialization aligned with the characteristics of a technology-driven industry; strengthen certification and testing infrastructure
  - Agricultural machinery: Develop global maintenance systems; transition toward smart and eco-friendly machinery
  - Smart farms: Internalize core technologies; establish post-exhibition follow-up management systems; develop ODA-linked export models
  - Pesticides: Reduce dependence on imported raw materials to improve supply stability; transition product portfolios toward eco-friendly options
  - Fertilizers: Stabilize raw material procurement; enhance competitiveness through low-carbon and precision fertilization technologies
  - Veterinary pharmaceuticals: Expand the industrial ecosystem and secure global distribution networks based on product quality competitiveness

- Pet food: Pursue high value-added strategies centered on functional and premium products; strengthen brand recognition
- Agri-food: Promote product innovation aligned with premium and eco-friendly trends; develop branding strategies leveraging K-culture

- The results of the input–output analysis and expert surveys show that the K-Food+ sector forms the following industry linkages along the value chain:
  - Production-base cluster (Seeds–Fertilizers–Pesticides): Jointly influence crop growth and quality; integrated crop-management packages are effective
  - Production-technology cluster (Agricultural machinery–Smart farms): Strong synergies emerge from the convergence of automation and precision agriculture technologies
  - Processing/consumption cluster (Agri-food–Pet food): Synergy through byproduct circulation and joint marketing; additional linkages with other cultural industries such as K-beauty and K-culture

Policy Suggestions

- As the consolidated outcome of this study, export expansion strategies and inter-industry linkage strategies were proposed for the K-Food+ sector by integrating the industries analyzed in both the first and second years (agri-food, pet food, seeds, smart farms, and upstream industries). These recommendations constitute actionable policy measures derived from industrial structure

analysis, policy analysis, export competitiveness assessments, input-output analysis, and expert evaluations. Three strategic pillars were established: (1) stabilization of production and supply bases, (2) strengthening technological and quality competitiveness, and (3) improving market access and global outreach. These directions reflect the recurring issues identified in the analysis: an unstable raw material supply, insufficient alignment with global quality standards, burdensome logistics costs, and limited local certification and marketing capacity. Specific K-Food+ export expansion measures include stabilizing the procurement of raw materials, components, and equipment; establishing contract farming, stockpiling systems, and smart farm-based raw material zones; enhancing compliance with global standards through quality control, standardization, and smart technologies; reinforcing R&D for functional and premium products; expanding logistics and cold-chain infrastructure; and developing global marketing platforms linked to K-culture and K-beauty.

- K-Food+ industries exhibit significant differences in country-specific demand, competitiveness levels, technological maturity, and policy environments, indicating a need for industry-differentiated export strategies. Accordingly, export expansion strategies were proposed for the industries analyzed in the second year—agri-food, pet food, seeds, and smart farms—based on their characteristics. Specifically, the seed industry requires high value-added customized variety development, strengthened international certification and testing systems, and enhanced overseas joint demonstrations through ODA platforms such as the Korea Partnership for Innovation of Agriculture (KOPIA).

The smart farm industry requires the internalization and standardization of key components, sensors, and control technologies; expansion of international package models through overseas demonstration projects and ODA; and integrated standards for energy, communications, and data, along with robust A/S and maintenance systems. The pet food industry needs differentiation through functional raw materials and premium products, stabilization of raw material supply, joint logistics and packaging models, and brand expansion grounded in the K-lifestyle (pet culture). The agri-food industry requires export-dedicated raw-material supply chains (contract farming and smart farm production zones), advanced quality management for fresh and processed products (IoT and blockchain traceability), R&D for premium and functional foods, region-based Geographical Indication (GI) specialization, strengthened cold-chain and international logistics hubs, and global branding strategies linked to Hallyu and K-beauty.

- Beyond industry-specific strategies, this study presents interindustry linkage strategies for generating synergies across the K-Food+ ecosystem. Based on the linkages identified through the input–output analysis and expert surveys, the following models are proposed: (1) Technology and production-based linkages, including a K-Agri Tech integrated package combining seed–machinery–smart farms; a data hub integrating growth information, environmental control, and operational data; and joint demonstration and modular turnkey-type export packages. (2) Eco-friendly input-material linkages, including integrated solutions across seeds, fertilizers, and pesticides (+ veterinary

pharmaceuticals), and the introduction of a K-Green Input eco-friendly certification scheme. (3) Consumer-goods and branding linkages, including joint market expansion for functional and premium products centered on agri-food and pet food, byproduct circulation systems (agri-food processing byproducts → pet food raw materials), and global brand expansion linked with K-culture and K-beauty. These linkage models represent key strategies for transforming the K-Food+ sector from individual industry-based exports to an integrated ecosystem-driven export platform.

A Study on Industrialization Strategy of Green-Bio Industry (Year 2 of 2) - Natural and Food materials

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Purpose of Research

- Amid the intensification of global challenges, including climate change, resource depletion, and food crises, bio-based industries are emerging as a critical alternative. The Green Bio industry, which integrates biotechnology into the agricultural and food sectors, is now globally recognized as a key future industry, driven by major national strategies in the US (National Biotechnology and Biomanufacturing Initiative) and the EU (European Bioeconomy Strategy). This international trend is accelerating the industrialization and market diffusion of biotechnology.

- Despite this global momentum, Korea's domestic Green Bio sector, while supported by its "Green Bio Industry Promotion Strategy (2023)," faces significant structural impediments. The technological, industrial, and institutional foundations remain weak. This study identifies the natural products and food materials sectors as a critical bottleneck hindering national progress in the bioeconomy.

- These sectors-which create value by extracting functional ingredients from natural resources or imparting functionality to agricultural products-are plagued by a heavy reliance on imports. This is a direct consequence of an unstable domestic supply chain and a lack of quality standardization, evidenced by the fact that domestic raw materials account for a mere 31.8% of consumption ("Survey on Raw Material Consumption in the Food Industry, 2023"). This structural weakness is exacerbated by inadequate industrial classification and statistical systems, which severely limit effective policy diagnostics and intervention.

- This study, therefore, constitutes the second-year investigation of the two-year "Research on Growth and Industrialization Strategies for the Green Bio Industry." Following the first-year (2024) analysis of the seed and microbiome industries, this research aims to derive growth and industrialization strategies centered specifically on the Green Bio natural products and food materials sectors.

- To achieve this, the study pursues four primary objectives. First, it will comprehensively analyze the domestic and international industrial conditions, policy environments, and technological levels to identify growth opportunities and constraints. Second,

it will empirically analyze the entire value chain-from development and production to commercialization and distribution-to identify bottlenecks in the industrialization process. Third, it will review policy trends and advanced case studies from regions such as the EU and Japan to draw implications for institutional reform. Finally, by synthesizing these findings, the study will propose specific policy and industrial response strategies, along with actionable tasks, to foster the growth and industrialization of this critical domestic industry.

Research Method

- This study employed a comprehensive mixed-methods approach to analyze the technological, industrial, and institutional landscape of the Green Bio natural products and food materials industry. The methodology was designed to first identify structural challenges and then formulate actionable growth strategies. This approach integrated six key components: a comprehensive literature review, statistical analysis, on-site field investigations, quantitative survey research, qualitative case studies, and a series of expert advisory conferences for data triangulation and validation.

- The research commenced with an extensive review of domestic and international secondary data. The domestic analysis focused on policy and industrial reports from key Korean institutions (e.g., IPET, National Biotechnology Policy Research Center) to map the current policy environment. The international review centered on the EU's "European Bio-economy Strategy" and Japan's

advanced functional food frameworks (e.g., FFC, FOSHU) to draw critical implications for institutional reform. To compensate for deficiencies in official domestic statistics, this review was supplemented by a quantitative statistical analysis, which used the "Survey of the Bio-industry" as a foundational dataset and enriched it with international market research (e.g., The Business Research Company, Nutrition Business Journal) and data from domestic agencies (e.g., MFDS, KoreaBIO).

- The core of the empirical investigation relied on extensive primary data collection. First, a large-scale survey research project was conducted by Korea Data Network (July-September 2025). This included in-person interviews with 156 enterprises spanning the entire value chain (development, production, and distribution) to ascertain industrial realities. Concurrently, a bifurcated online consumer survey (Natural Products, n=452; Food Materials, n=721) was administered to analyze consumer segmentation, purchasing behaviors, and product preferences.

- This quantitative data was further contextualized through in-depth qualitative fieldwork. On-site investigations involved direct visits to local government research institutes, industry support agencies, and private enterprises to identify practical, on-the-ground challenges and policy needs. Furthermore, focused case studies were conducted- using in-depth interviews with both raw material cultivators and processing enterprises-to specifically analyze the critical linkage structures between farms and firms, assess domestic material utilization, and identify R&D commercialization bottlenecks.

- Finally, to ensure the validity and coherence of the findings, a series of 12 expert advisory conferences was convened. This crucial step involved a diverse array of stakeholders from industry, research institutes, academia, and government. These conferences served to triangulate the data and vet the feasibility of the proposed development strategies. Discussions focused on the technical aspects of the Upstream-Midstream-Downstream value chain, functional verification systems, and public-private partnership (PPP) models, with the outcomes directly incorporated into the final policy recommendations.

Main Findings

- This study examines the structural, institutional, and technological challenges confronting Korea's Green Bio industry, particularly in the sub-sectors of natural products and functional food materials. Although this field constitutes a high-value-added pillar of the emerging bio-economy, its global competitiveness remains weak despite its strong growth potential. The analysis identifies systemic institutional fragmentation as the principal obstacle to industrialization.

- Chapter 2 establishes the conceptual framework, defining natural products as functional substances derived from bio-resources and food materials as agricultural products endowed with physiological functionality. A review of the domestic regulatory landscape reveals that, unlike the integrated systems of the European Union (EU) and Japan, Korea's framework is inconsistent and compartmentalized, with fragmented legal definitions and

uncoordinated oversight across the food, pharmaceutical, and cosmetics sectors.

- Chapter 3 further investigates this fragmentation within the policy environment. Administrative authority is dispersed across multiple ministries-MAFRA, MFDS, MOTIE, and MSIT-resulting in overlapping mandates and institutional dualism. While local governments (e.g., Jeollanam-do, Gangwon-do) are pursuing regional specialization strategies, these efforts are hindered by weak coordination and suboptimal governance structures. Although the proposed Green Bio Industry Promotion Act represents an attempt at institutional integration, the sector remains constrained by inefficiencies associated with its fragmented policy architecture. Industrially, the domestic ecosystem is characterized by research-centric structures, low commercialization capacity, insufficient quality standardization, and an underdeveloped verification system, all of which create persistent bottlenecks.

- Chapter 4 presents an empirical assessment of the entire industry value chain, based on survey data disaggregated into three stages: Upstream (procurement), Midstream (development), and Downstream (commercialization). Results indicate a critical imbalance across stages.

  - Upstream (Raw Materials): Although the utilization rate of domestic inputs appears high (75.5%), the procurement base is unstable, with 43.5% of firms relying on external suppliers and only 13.9% engaged in systematic contract farming. Standardization mechanisms remain weak, with limited adoption of standard contracts (44.4%) and incomplete quality databases (58.0%).

- Midstream (Development & Verification): This stage constitutes the core industrial bottleneck. Only 19.9% of firms maintain in-house R&D units, 31.4% have dedicated QC functions, and certification capacities are low (GMP 31.4%, ISO 18.7%). Less than 20% conduct safety or human application trials. Consequently, production is dominated by low-value primary processing (e.g., drying, grinding), with limited progress toward high-value functional verification or formulation.
- Downstream (Commercialization): Although 68.6% of firms manufacture products with "functional" attributes, only 15.0% are officially approved as Health Functional Foods by MFDS. Market penetration remains limited, and exports are minimal (9.6%), primarily due to weak certification and standardization frameworks.

- Chapter 5 contrasts Korea's fragmented policy regime with the integrated and successful models of Japan and the EU. Japan's Foods with Function Claims (FFC) system-allowing function claims even for fresh agricultural produce-has effectively linked local agriculture with industry, generating over 8,000 registered products. Similarly, the EU's Novel Food Regulation provides a unified, science-based authorization mechanism that ensures both safety and market access. The comparison underscores that Korea's disjointed regulatory framework, which delays the translation of R&D outputs into marketable products, must be restructured to mirror the institutionalized verification and integrated governance systems of these advanced economies.

- Building on these insights, Chapter 6 proposes a comprehensive implementation framework for the full-cycle industrialization of the Green Bio natural products and food materials sectors. The framework adopts a phased and role-differentiated governance model to overcome the institutional fragmentation identified throughout the study. Under this model, the central government acts as the Institutional Architect, responsible for designing foundational "outputs" such as legislation, national standards, certification criteria, and integrated infrastructure, while ensuring inter-ministerial coherence. Local governments, in turn, function as Implementation Agents, tasked with delivering sustainable "outcomes" through regional hubs, verification programs, and direct enterprise support.

- The framework outlines 16 strategic tasks, categorized into value chain-wide common tasks and two sector-specific initiatives, all designed to alleviate key bottlenecks.
  - Upstream (Raw Materials): Establish stable, region-linked supply systems by standardizing pre-processing protocols and building quality and traceability databases.
  - Midstream (Materials): Mitigate verification bottlenecks by implementing one-stop regulatory platforms that integrate R&D, pilot-scale production, and certification to shorten commercialization timelines.
  - Downstream (Products): Facilitate market access and exports through support for international certifications (e.g., FDA GRAS, NDI) and the introduction of a national functional data certification mark to enhance consumer trust.

- For sector-specific strategies, the framework recommends:
  - Natural Products: Institutionalizing contract farming models based on regionally specialized crops to secure stable, standardized domestic raw material supplies.
  - Food Materials: Reforming the functional claims system to strengthen scientific substantiation and adopt a more flexible, autonomous approach-drawing from Japan's successful FFC model-to expand markets for functional agricultural products.
- Ultimately, this study concludes that advancing Korea's Green Bio natural products and food materials industry requires a decisive shift away from fragmented, short-term support policies toward a coherent, full-cycle governance structure. Such a structure must integrate central policy design with regional implementation, ensuring that institutional "outputs" are effectively translated into tangible industrial "outcomes."

Policy Suggestions

- First, it is imperative to standardize the Upstream stage (cultivation and pre-processing of functional raw materials) and stabilize its associated supply chain. This initial stage currently suffers from low industrial reliability and weak inter-sectoral linkage, primarily due to deficiencies in quality management, traceability, and contract-based frameworks. Consequently, standardized pre-processing packages- which delineate criteria for washing, drying, and storage, and include standard testing protocols-must be established. This must be coupled with an integrated management system founded on a quality and traceability

database (DB). In the short term, predictability regarding quality, delivery, and volume should be enhanced through the provision of testing and analysis vouchers and the expanded implementation of Service Level Agreements (SLAs). In the mid- to long-term, supply-demand forecasting, stockpiling, and supply adjustment functions must be reinforced by establishing a regional- industrial linked supply system, operated via regional integrated information systems.

- Second, at the Midstream stage (material processing, standardization, verification, and certification), the chief objectives are to secure process reproducibility and establish an integrated verification and regulatory approval system. Complexity in process standardization and verification procedures was identified as a primary bottleneck by material development enterprises. To address this, a short-cycle verification system linking prototype development, pilot-scale production, and standards certification must be constructed. Concurrently, an integrated "package-type" approval framework-providing comprehensive support for active ingredient analysis, pre-clinical trials, and safety testing-should be implemented. This system should operate under a structure where the central government provides standards, judgment criteria, and principles of mutual recognition, while regional hubs manage testing, verification, and data quality assurance. This aims to significantly reduce the time-to-market. In the long term, this must evolve into a full life-cycle verification governance system that incorporates human application trials (clinical studies), regulatory integration, and a systematic framework for the public disclosure and renewal of functional data. To ensure that these technological

and institutional foundations operate effectively, it is essential to secure a workforce equipped with competencies in regulatory affairs, licensing, and data management. In parallel, an industry-academia-government collaborative framework for practical training and human resource development should be established. Such a system would strengthen professional capacity in the field and lay the groundwork for sustainable industrial growth.

- Third, the Downstream stage (commercialization and sales) requires parallel support for domestic market penetration and international certification. To secure market trust in functional products, a QR-code-based functional data certification mark system and a promotional framework centered on scientific evidence must be introduced. To facilitate market entry, export-linked incentives-such as vouchers for obtaining foreign certifications (e.g., FDA GRAS, NDI), export consultations, and buyer-matching programs-should be provided. Global entry barriers should be mitigated by establishing mutual recognition systems between domestic regional hubs and international counterparts. In the mid- to long-term, a virtuous cycle between domestic consumption and exports must be fostered through linkage with public procurement and support for co-branding initiatives.

- Fourth, the natural products sector requires the institutionalization of contract farming centered on regionally specialized crops. It is necessary to establish a regional industrial model that institutionalizes this resource-based contract farming and establishes a GACP (Good Agricultural and Collection Practices)-based quality assurance

system. This model must integrate standardized cultivation, pre-processing, verification, and contracts. Incentives, such as R&D and export vouchers or preferential points in public procurement, should be allocated based on the utilization rate of local raw materials. This will strengthen cooperation among farms, enterprises, and local governments, thereby enhancing the self-sufficiency of domestic source materials.

- Fifth, the food materials sector necessitates increased flexibility in the functional claims system and improvements to consumer-centric labeling. To expand the scope of functional ingredients, several measures are required: introducing a fast-track approval system for ingredients already verified internationally; linking data between the Functional Ingredient Bank and the Ministry of Food and Drug Safety (MFDS); and adopting an autonomous functional claims system (modeled after Japan's Foods with Function Claims, FFC). To mitigate consumer confusion, negative phrasing on labels should be replaced with official government-certified symbols. Furthermore, Nutrient Profiling Model (NPM) criteria must be applied to prevent the excessive or abusive use of claims. A new system permitting functional claims on fresh agricultural produce should be established, linking cultivation management protocols with public R&D to reinforce a symbiotic structure between agricultural producers and food enterprises.

- Finally, achieving the growth and industrialization of the Green Bio natural products and food materials industry demands a governance framework that systematically links the policy design of the central government with the on-site execution by local

governments. The central government must act as the principal policy architect, establishing the legal, institutional, and policy frameworks. It must provide industry-wide direction by organizing the institutional foundations for quality standards, safety verification, standard contracts, and data management. Furthermore, it must formulate national-level strategies that integrate R&D, certification, and exports, ensuring regulatory coherence through inter-ministerial collaboration. Conversely, local governments function as the executing bodies responsible for operationalizing these policies. They must manage verification and commercialization programs and establish enterprise support infrastructure centered around regional hubs. They translate national policy into tangible industrial outcomes through field-level projects, while promoting participation via performance data feedback loops and incentive systems. Therefore, a structure must be established that facilitates full-cycle industrialization by clearly delineating roles: the central government as the institutional designer and local governments as the implementation agents.

Scenarios of Food Security Crisis and Establishment of Response System (Year 2 of 2)

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Purpose of Research

- This study aims to develop a national food security crisis response system grounded in comprehensive crisis scenarios that incorporate both domestic and global risk factors. The first year of the research established strategic directions for building and operating such a system. Building on this foundation, the second year focused on developing a simulation model tailored to diverse crisis situations and designing a feasible operational framework. Specifically, the study constructed a simulation model capable of assessing and responding to multiple food security crisis situations, defined crisis stages with corresponding response guidelines, and proposed an operational framework that specifies institutional roles and coordination mechanisms across relevant agencies.

Research Method

- The methodologies in this study include a review of domestic and international literature, basic statistical analysis, examination of relevant policies and institutional frameworks, optimization model analysis, expert surveys, and consultations through research advisory meetings.

Main Findings

- Chapter 2 identifies the key factors threatening food security and evaluates the current policy framework for responding to food security crises. Based on this assessment, the study underscores the necessity of establishing a food security crisis response system.

- Chapter 3 examines food security crisis response strategies in Japan, Belgium(EU), and international organizations. Japan enacted the Act on Measures for Food Supply Shortage on April 1, 2025, establishing a framework to prepare for and respond to signs or occurrences of food supply disruptions. The Act enables preventive and initial response measures based on the Response Headquarters' guidelines when warning signs emerge. In the most severe crisis stage—when minimum food supply for the population cannot be secured—the Act provides a foundation for calorie-focused domestic production, fair allocation and rationing of limited food resources, and stabilization measures for rapidly rising food prices.

- The European Food Security Crisis Preparedness and Response Mechanism(EFSCM), functioning as a consultative platform, has prepared recommendations to enhance speed and accuracy in crisis communication across the food supply chain, thereby

providing a shared basis for stakeholders to develop communication strategies. Belgium responds to temporary disruptions or price surges through its Food Crisis Plan, while its National Resilience Plan aims to strengthen resilience against severe disruptions such as war or breakdowns in energy and logistics systems.

- FAO emphasizes the Early Warning–Early Action(EWEA) framework, which links early warning information directly to early response. Under EWEA cooperation with FAO, the Philippines successfully mitigated the 2024 food crisis by making early procurement decisions despite India's rice export ban prompted by El Niño forecasts.

- Chapter 4 develops an optimization-based food crisis response model to support food supply decision-making. Centered on minimizing procurement costs, the model aims to identify strategies for expanding domestic production that ensure the minimum caloric requirements of the population during the most severe(Stage 3) crisis. The analysis assumes that supply shortages for two or more items(corn, wheat, soybean) persist for at least one year due to import restrictions, resulting in insufficient per capita caloric supply the following year(Stage 3 crisis definition). Additional scenarios include reduced minimum calorie requirements, declining domestic production caused by climate change, etc.

- Results show that procurement costs and required cultivated area decrease as the minimum guaranteed calorie level is lowered. The availability of tradeable crops allows a substantial share of calories to be supplied through imports of non-restricted items,

making the ratio of available cultivated land less influential.

- When a constraint is added to maintain a caloric self-sufficiency rate above 29.4%—the baseline level—both procurement costs and required cultivated area increase, with barley(winter crop) and soybeans(upland crop) emerging as critical crops. Under a scenario where wheat, soybeans, and corn—the most vulnerable crops—are all import-restricted, maximum self-sufficiency reaches 86% when maintaining 100% caloric coverage.

- If the model is run without imposing caloric self-sufficiency constraints, the required caloric supply can be met with existing cultivated areas, assuming free importation of non-restricted crops. However, in reality, securing alternative crop imports may be difficult when the three major grains become unavailable, indicating that maintaining current farmland area is essential for maximizing caloric self-reliance.

- Chapter 6 proposes an operational framework for the food security crisis response system. Crisis stages are defined across four levels(0 to 3) based on the duration and severity of supply shortages. Stage 0 represents a preventive or normal condition where supply and prices remain stable, while Stages 1–3 denote crisis conditions. The study proposes that a supply decline of 20% or more compared to average levels defines a Stage 2 crisis, while a per capita daily calorie supply below 1,850 kcal defines a Stage 3 crisis.

- Operational responsibility is differentiated by crisis stage: a Food Crisis Response Committee for Stages 1–2 and a Food Crisis Response Headquarters for Stage 3. As the severity of the crisis escalates, whole-of-government coordination becomes essential, involving the Ministry of Agriculture, Food and Rural Affairs as the lead agency alongside the Ministry of Economy and Finance, Ministry of Foreign Affairs, Ministry of Oceans and Fisheries, and the Ministry of Food and Drug Safety.

- Corresponding countermeasures are presented for each stage: Stage 0 focuses on maintaining and strengthening domestic production and supply chains; Stages 1–2 emphasize shipment and sales adjustments, import facilitation, and expansion of domestic production; Stage 3 prioritizes calorie-focused production expansion, fair allocation of scarce food supplies, and stabilization of sharply rising food prices.

Policy Suggestions

- For Korea to operate an efficient and effective food security crisis response system, establishing a clear legal foundation is essential. A dedicated Food Security Act should reflect constitutional values, including the public's right to food access and the state's responsibility to secure stable food supply in both normal and crisis conditions. This includes provisions on conserving and managing farmland and water infrastructure, protecting and fostering the seed industry, and ensuring efficient operation of strategic reserves. The Act must clearly define the government's obligations to secure stable food supply during crises, ensure

food access for the population, and establish a response headquarters capable of implementing rapid and effective measures. It should also authorize the government to request or instruct producers and industry stakeholders to support supply stabilization at different crisis stages.

- Expert surveys indicate that expanding domestic storage facilities and increasing stockpiles are considered both highly important and highly effective. Therefore, Korea should select key items for stock expansion based on global supply conditions, price volatility, and domestic inflation impacts. Drawing from the Switzerland case, strengthening private sector involvement in stockpiling is also recommended.

- Securing adequate financial resources is critical to ensure swift and effective crisis response. Establishing a joint Food Crisis Response Fund involving the central government, local governments, and private sector stakeholders may be considered. The fund could support stockpiling, market stabilization through import adjustments, emergency procurement during crises, restoration of production capacity, and crisis-related research.

- Conducting regular simulation-based crisis exercises will enable Korea to validate the effectiveness of stepwise response measures and identify system gaps. This requires scenario-based training built on risk assessments and collaboration among relevant ministries, local governments, private companies, and producers. Issues identified through exercises should be classified into short- and long-term tasks for follow-up improvement. In addition, relevant laws and guidelines should be reviewed and revised based on expert consultation.

A Panel Survey for Rural Villages (Years 6 of 10)

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Purpose of Research

- This study aims to examine long-term demographic, social, spatial, economic, and community changes in rural areas by conducting annual panel surveys over six years in 103 rural villages across the country. To address the limitations of existing rural statistics—which often lack temporal continuity and do not sufficiently capture village-level dynamics—the study integrates village-level and household-level surveys with in-depth case studies to provide a comprehensive and grounded understanding of actual changes taking place in rural communities.

- In the sixth year of this long-term study, the in-depth thematic focus was placed on changes in the rural settlement system. The objective was to empirically analyze how rural areas maintain and reorganize their settlement foundations in the midst of rapid

population aging, declining population, lifestyle changes, and increasing mobility, and to propose policy directions for future settlement-system-based rural development.

Research Method

- This long-term research project spans ten years, and 2025 marks the sixth year of its implementation. The study followed the existing analytical framework while conducting the core panel surveys. A total of 103 rural panel villages and 360 rural panel residents were surveyed to investigate and analyze the conditions and changes occurring in rural communities.

- The panel village survey, which follows the same structure each year, covers indicators related to population and households, economic activities, community operations, and the physical environment. In the sixth year, additional questions were added concerning settlement patterns, activity spaces, and local service use to better analyze changes in the settlement system. In addition, the research team conducted on-site visits to 11 villages to interview village representatives and residents, and to observe settlement conditions firsthand to validate the survey outcomes.

- The rural panel resident survey-selected 10–15 villages from among the panel villages and drew a sample of 360 residents. The sample focused on young and middle-aged adults to analyze long-term changes in the region's human-resource base and living conditions.

- To analyze the in-depth research topic—changes in the rural settlement system—expert consultations were conducted with specialists in urban and regional planning, community studies, and regional economics. These consultations helped identify key components of the settlement system, drivers of change, and emerging policy issues. The identified issues were examined in relation to the panel survey results to assess how they manifest in actual rural settings. Additional local case studies were used to identify diverse patterns of settlement-system change and derive policy implications.

Main Findings

- The rural panel survey shows that although population decline and aging continue in rural areas, the pattern does not represent a simple linear decline. Even as population decreases, the number of households continues to increase—a phenomenon described as "population dilution." The rise in second homes and temporary or seasonal residences indicates the growing coexistence of permanent and non-permanent residents, suggesting that rural villages are increasingly functioning not only as places of residence but also as spaces for temporary living, recreation, and social connection.

- The economic structure of rural communities remains centered on agriculture, yet cooperative labor and collective farming activities are decreasing. In contrast, individual and household-based economic activities are increasing. The utilization of vacant houses and unused facilities for small-scale businesses,

tourism, and processing is expanding, leading to the formation of a more diversified and service-oriented rural economy.

- The demographic composition of villages is shifting toward a coexistence of long-term residents and newcomers. While traditional community activities persist, participation among younger residents and newcomers remains limited, signaling the need for community restructuring. Residents report high satisfaction with the natural environment and community relations, but relatively low satisfaction with employment, medical services, and daily amenities, revealing persistent weaknesses in basic living infrastructure.

- The analysis of the settlement system shows multi-layered changes unfolding across settlement spaces, service-use patterns, economic structures, and community operations. The traditional hierarchical structure—ranging from higher-tier centers to lower-tier centers and then to hinterland villages—is weakening, while dispersed functional nodes such as small schools, welfare facilities, and village enterprises are emerging across various spatial locations. Some formerly peripheral villages have even gained new significance as life spheres due to increases in in-migrants.

- Service-use patterns also reflect diversification. Despite the weakening of township-level centers, residents are not simply shifting to higher-tier service centers. Instead, multi-layered service networks have emerged, combining nearby local centers, municipal centers, and online platforms. The expansion of non-face-to-face services further contributes to the flexibility of service-use networks.

- Economic activities in some villages are diversifying to the extent that villages are re-emerging as economic hubs. Community-based enterprises and cooperatives are increasing, and new economic structures are forming around diversified income-generating activities.

- Communities are experiencing dual changes: the weakening of traditional organizations and the emergence of new systems such as residents' councils, cooperatives, and village enterprises. As community membership becomes more diverse, the need for conflict mediation and inclusive governance is increasing.

- Overall, rural areas are entering a phase of "restructuring," maintaining essential functions while adapting to new conditions under the structural pressure of population decline. These changes are complex and intertwined across settlement, livelihood, economic, and community dimensions.

Policy Suggestions

- Although rural areas are undergoing population decline, they continue to maintain essential living foundations and community functions while adapting to new conditions such as the expansion of temporary residence, diversification of economic activities, and growing multi-layered living spheres. Policy efforts should therefore focus on establishing a sustainable settlement system that supports stable daily life in rural areas, even under demographic decline.

- The central government should ensure the minimum level of essential living conditions in all rural areas by providing basic infrastructure and services. Local governments, in turn, should develop autonomous settlement-system plans that reflect local resources and spatial characteristics. Classifying rural regions into settlement-system types and preparing type-specific strategies is essential for effective policy implementation.

- Reorganizing rural settlement spaces is necessary. While maintaining the basic central-place structure, functional linkages based on actual living spheres must be strengthened. As the role of township-level centers weakens, the functions of small-scale living hubs should be redefined. Efforts should also be made to utilize vacant houses, improve aging infrastructure, and introduce management standards for second homes and temporary dwellings. Unused spaces such as closed schools and old warehouses should be redeveloped into mixed-use hubs for housing, economy, and community services.

- Living infrastructure and employment foundations should be strengthened in an integrated manner. Medical, caregiving, and daily living services must adopt flexible delivery modes—such as mobile, visiting, and remote services—so that even transportation-disadvantaged areas can maintain essential accessibility. Beyond agriculture, locally-rooted service industries should be supported through start-up assistance, social-economy networks, and local-value-chain development.

- Community capacity building and inclusive governance are also critical. Structures enabling active participation across generations,

social groups, and in-migrants are needed. Residents' councils and intermediate-level local governance organizations can play important roles in addressing local challenges. Strengthening community leadership, settlement support for newcomers, and cultural programs will contribute to resilient and inclusive local communities.

- Multi-layered service systems should be established by combining township-level basic infrastructure with remote services, DRT (Demand Responsive Transit), and telemedicine to support low-density and aging areas. Expanding digital infrastructure is fundamental to ensuring equal access to services and maintaining functional living territories.

- Finally, a region-led development system is essential. The central government should guarantee minimum living standards, while local governments and communities develop and implement differentiated development strategies. Participatory planning processes—such as community visioning and village future design—should be encouraged, and the capacity of local implementation organizations must be strengthened to build sustainable regional governance.

A Study on the Transition of Rural Policy in Response to Low Birth Rate and Hyper-aging (Year 2 of 2)

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Purpose of Research

- This study begins from the recognition that the structural crisis confronting rural Korea amid declining birth rates and rapid population aging is not merely a demographic issue, but a systemic challenge reflecting the weakening of communities' capacity for self-reproduction. Rural areas are increasingly burdened by labor shortages, a shrinking consumer base, and the collapse of essential living services—conditions that threaten their long-term sustainability. In response, this research aims to propose a new policy direction that moves beyond conventional

population-inflow strategies toward approaches that sustain residents' quality of life and maintain community functions under demographic contraction. The study emphasizes restructuring the operational unit of rural policy to the eup-myeon (township) level and supporting the formation and activities of resident-led organizations that can effectively deliver services in such key areas as care, everyday living, and agricultural production.

Research Method

- A mixed-methods approach was employed, combining literature review, statistical analysis, in-depth interviews, and focus group discussions (FGDs) to identify how low fertility and aging are reshaping rural society and to capture residents' perceptions and adaptive practices. The study also conducted detailed case analyses of eup-myeon-level community organizations engaged in local care, living services, and cooperative agricultural production. The results from these analyses were synthesized to develop concrete policy directions and tasks for systemic transformation of rural policy.

Main Findings

- Findings confirm that resident practice organizations at the eup-myeon level play a pivotal role as new policy implementation units. In cases such as Songak-myeon and Janggok-myeon, residents identified local problems, set their own agendas, and independently planned and executed services in diverse domains

including care, education, environment, and daily conveniences. These initiatives function as alternative local systems that compensate for the retreat of public and market services. However, their operations remain project-based and unstable due to temporary administrative and financial support.

- The combined pressures of aging and depopulation have sharply increased care needs in rural communities. Yet, existing formal care systems—such as the Long-Term Care Insurance scheme—fail to encompass everyday assistance and emotional or relational care. This study thus highlights the necessity of a community-led care model in which resident organizations, local governments, welfare institutions, and public health centers collaborate on an ongoing basis. Cases in Goseong, Hongseong, and Geochang demonstrate the potential of such models, but also reveal their limited sustainability in the absence of institutionalized funding and staffing mechanisms.

- Access to basic living services in rural areas has also deteriorated rapidly. Declining demand has made it difficult to sustain daily services such as laundry, bathing, restaurants, and small retail shops. Public services, likewise, have contracted under cost-efficiency pressures. In response, some communities have established cooperative laundries, village stores, and multi-functional community hubs to fill service gaps. However, these efforts remain fragile, as they rely heavily on volunteer labor without stable operating and personnel cost support.

- In agriculture, labor shortages and population aging have underscored the growing need for collaborative production and management. Unlike in other countries, Korea lacks institutional frameworks recognizing or supporting joint farming and shared equipment systems. Although small-scale collaborative initiatives are emerging, their expansion is constrained by limited legal recognition and financial assistance.

- Overall, the study demonstrates that rural policy must evolve from a focus on population growth to one centered on maintaining community functionality and residents' quality of life amid demographic decline.

Policy Suggestions

- Institutional Restructuring: Designate the eup-myeon level as the core implementation unit of rural policy and formally recognize resident organizations as policy partners. Establish a stable fiscal framework that supports not only facility investment but also recurrent costs such as operations and personnel.

- Community-Based Care: Institutionalize a care network linking resident groups, local governments, welfare agencies, and health centers to supplement formal care systems. Central and local governments should secure consistent fiscal resources to sustain these networks.

- Living Service Infrastructure: Promote integrated and localized models of community-managed spaces and living social

infrastructure (SOC) to stabilize access to essential everyday services.

- Collaborative Agriculture: Provide institutional recognition and policy support for cooperative production and management, enabling small-scale collaboration to evolve into sustainable, community-based agricultural systems.

- Paradigm Shift in Policy Goals: Reorient rural policy from population expansion toward ensuring a dignified standard of living for current residents. A policy transition that sustains rural life and vitality amid low fertility and aging is the essential task for the future of rural development.

Analysis of the Farmland Lease Market and Tasks for Improvement

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Purpose of Research

- This study analyzes the structural changes and driving forces within South Korea's farmland lease market to derive policy recommendations aimed at normalizing the market function and enhancing farmland utilization efficiency. First, we empirically investigate the structural changes in the lease market and the heterogeneous drivers of demand and supply. Second, we analyze the impact of current agricultural and farmland policies on the lease market and diagnose the sources of market distortion. Finally, we seek a comprehensive understanding of the farmland lease market by combining objective quantitative analysis with subjective perception analysis.

Research Method

- This study employed a multi-layered approach to diagnose market issues and formulate policy tasks, utilizing the following methods.
  - Literature & Comparative Review: we conducted a comprehensive review of domestic and international studies, laws, and systems, including a comparative analysis of farmland lease models in major countries (e.g., Japan, Germany, France).
  - Statistical & Econometric Analysis: we analyzed the market using diverse official data sets, including the Census of Agriculture, Farm Household Economy Survey, Crop Production Cost Survey, and KRC's Farmland Rent Survey.
  - Surveys & Fieldwork: we surveyed both farmers and non-farmers to capture subjective perceptions and contextual information beyond official statistics. Expert consultations and field investigations were integrated to enhance the objectivity and depth of the analysis.

Main Findings

- In chapter 2, the analysis of the farmland lease system shows evolution from principal prohibition (farmer-only ownership) to exceptional allowance, recently improving with tenant protection and data-based administration (Farmland Register). Market trends show the leased area peaking in 2013 and declining afterward, with the farm structure shifting towards owner-operators. A polarization is evident: payment is becoming marketized (cash-centric), while free leases (non-market transactions among kin/acquaintances) are also significantly increasing.

Crucially, the simultaneous drop in the lease rate and leased area indicates a structural problem where both market demand and supply bases are simultaneously weakening.

- Chapter 3 shows that the market's structural change is marked by an overall contraction (reduced leased area and tenant households) driven by policy factors like direct payments, which increase landowners' incentives for direct self-cultivation. Internally, polarization is deepening, with leased land concentrating among a few large-scale farms (over 10 ha), reflected by the rise in the Gini coefficient for leased area (from 0.54 in 2000 to 0.66 in 2020). This duality stems from differing motivations: high-income/succession farmers expand leasing as a growth strategy, while small-scale farmers participate mainly for subsistence due to a lack of purchase capital.

- In chapter 4, we identified the drivers for supply and demand using a panel Tobit model and survey data. Demand is high among younger managers (under 50) and those with high agricultural income (especially rice). Farmers with high farm debt distinctly prefer expansion through leasing over purchasing. Intent to lease is more heavily influenced by social factors (e.g., trust) and institutional perceptions (contract stability) than by economic profitability. On the other hand, supply is dominated by older farmers (60s-70s and older) with high non-agricultural income and assets, and low agricultural income. However, excessive farm debt (over 300 million KRW) causes a management fixation effect, compelling potential lessors to continue farming and thereby restricting supply.

- In chapter 5, we show that the sharp contraction of the lease market observed between 2015 and 2020 is primarily attributed to the 2020 introduction of the smallholder direct payment, which motivated small-scale farmers to increase their operated area. This suggests an increase in formal self-cultivation (delegated farming) aimed at subsidy receipt, which constricted the supply of leased land. Furthermore, analysis of the capitalization effect (direct payment amount absorbed into rent) revealed a significant disparity: approximately 38% was absorbed when the landlord was a farmer, versus only 20% when the landlord was a non-farmer. This disparity empirically confirms the high potential for widespread sham self-cultivation (landlords effectively receiving the subsidy) on non-farmer-owned land.

Policy Suggestions

- First, policy incentives must be redesigned to prioritize stable leasing and genuine land utilization over formal self-cultivation so as to address farmland lease market distortions. This requires establishing rational retirement exit strategies for elderly farmers, as the current smallholder direct payment delays their retirement and induces formal self-cultivation. For instance, parts of the direct payment could be linked to long-term leasing via the Farmland Bank, or payments could be increased in conjunction with the Farmland Pension scheme. Furthermore, the 8-year self-cultivation capital gains tax reduction—a major incentive for sham farming—should be reformed. Tax benefits should be partially or fully granted when a long-term lease (10 years or more) is secured through the Farmland Bank, recognizing this

commitment as fulfilling the self-cultivation duty.

- Second, a customized support system is necessary to address the market's dual structure, tailoring assistance to both demand and supply entities. On the lease demand side, low-interest financial products should be provided to growth-oriented farms (even those with high debt), and farmland rent subsidies should be offered to young or new farmers facing entry barriers. On the lease supply side, a restoration guarantee system must be introduced to alleviate asset protection concerns for landlords. For farmers trapped in management fixation due to excessive debt, the management rehabilitation program should be expanded, linking debt adjustment to long-term leasing commitments.

- Third, the foundation of social and institutional trust, which critically influences lease demand and supply alongside economic factors, must be strengthened. This involves upgrading the Farmland Bank's role from simple brokerage to a comprehensive service platform offering dispute mediation, legal consultation, and restoration guarantees. To improve the current market structure (biased toward rice farming), the Farmland Bank should actively consolidate fragmented land, improve infrastructure, and supply customized plots suited for diverse farming types (e.g., orchards, facility farms). Finally, mentoring programs and similar soft policies should be implemented to help new and young farmers overcome local social network barriers, thereby enhancing overall market transparency and efficiency.

Country Partnership Strategy in Agriculture and Forestry Sector

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Research Objectives

- Korea's agricultural ODA has pursued quantitative expansion to contribute to global food security and the achievement of the Sustainable Development Goals (SDGs). To ensure qualitative improvements commensurate with this expansion—namely, enhanced development effectiveness and sustainability—a strategic approach combining partner country characteristics with Korea's comparative advantages in agriculture is essential. Central Asia faces common structural vulnerabilities, including production instability intensified by climate change, water and energy constraints, and ageing agricultural infrastructure. Korea's strengths in greenhouse horticulture technology and ICT-based

smart farming offer potential solutions to circumvent these structural challenges.

- This study was undertaken to propose strategic directions and implementation measures for international development cooperation in greenhouse agriculture with three Central Asian countries: Kyrgyzstan, Tajikistan, and Uzbekistan. The specific objectives are threefold: first, to identify country-specific cooperation needs and constraints through comprehensive analysis of each country's agricultural environment, climatic conditions, infrastructure, policy framework, current greenhouse agriculture adoption, and the technology acceptance levels of farmers and specialists; second, to propose facility types appropriate to national and regional characteristics (ranging from appropriate technology greenhouses to advanced smart farms), strategic crops, optimal locations, and an integrated value chain approach linking production, processing, distribution, and export; third, to develop strategies for establishing a sustainable greenhouse agriculture ecosystem encompassing technology transfer, human capacity building, public-private partnerships, and institutional foundation beyond mere facility introduction. Through this research, we aim to present a mutually beneficial cooperation model that enhances climate resilience and productivity in Central Asian agriculture whilst establishing foundations for Korean agricultural industries' overseas expansion.

Research Methodology

- To achieve the research objectives, the study first reviewed previous research published by domestic agricultural institutions, research organizations, partner country governments, agricultural research institutes, and international organizations. It then analyzed statistical data on the agricultural status and environment of the three target countries, as well as Korea's performance in implementing facility agriculture and smart farming projects.

- To assess the impact of climate change on agricultural productivity in Central Asia, a panel fixed-effects model was constructed using data on major vegetable crops. Additionally, to examine the effect of Korea's agricultural ODA on agricultural value-added in Central Asia, a panel regression model was employed.

- Survey research was conducted through local and domestic agencies, targeting both farmers and experts. Based on the farmer survey, frequency and cross-tab analyses were performed to understand farmers' acceptance of facility agriculture technologies and policies, as well as their challenges. An ordered logit model was used to analyze the intention to adopt facility agriculture. Based on expert surveys, the Analytic Hierarchy Process (AHP) method was applied to derive priority areas for international cooperation in facility and smart farming.

- A field visit was conducted to Uzbekistan, where facility agriculture is expanding, to identify the current application of facility systems, barriers to dissemination, and areas where technical cooperation could be supported through development assistance. Expert consultation meetings were held to discuss ODA strategies for facility agriculture in Central Asia. To ensure smooth research

progress, manuscripts were also commissioned to Dr. Kwangseok Joo (Director, KOPIA Kyrgyzstan) and Dr. Jaehyun Kim (Director, KOPIA Uzbekistan).

Main Findings

- The agricultural sectors of Central Asian countries face multiple challenges, including water scarcity, extreme climate variability, soil degradation, and labor shortages. The empirical analysis of climate change impacts on vegetable productivity revealed that technological factors, rainfall during the growing season (June–July), and high temperature–drought interaction during the harvest period significantly affect productivity. These challenges threaten food security and hinder sustainable agricultural development in the region.

- Facility agriculture, including smart farming, has the potential to address these problems and enhance productivity, quality, and export competitiveness, thereby contributing to the sustainability of agriculture in Central Asia.

- Central Asian countries have incorporated facility agriculture into their national development strategies and agricultural policies. However, there are differences in progress: Uzbekistan has implemented strong policy support to promote high-value horticulture and water-efficient facility agriculture, whereas Kyrgyzstan and Tajikistan have provided limited policy support. Greenhouse facilities are concentrated around major cities and in relatively mild climatic regions. Technological levels also vary

— Kyrgyzstan and Tajikistan primarily rely on vinyl greenhouses, while Uzbekistan has introduced more advanced and automated systems.

- Regarding constraints, high energy costs were found to be a major barrier in all three countries. Financial access was low in Kyrgyzstan and Tajikistan. Kyrgyzstan also lacked skilled labor, while Tajikistan suffered from weak institutional frameworks and the absence of unified facility guidelines. Even in Uzbekistan, farmers and operators lacked technical and managerial capabilities, as well as sufficient R&D and extension services.

- ODA case studies showed that in Kyrgyzstan, operations were suspended due to weak managerial capacity. In Kyrgyzstan and Tajikistan, high winter heating costs, power outages, and limited sunlight were major obstacles. Farmers across Central Asia faced challenges in expanding facility investments due to lack of collateral and high interest rates.

- Projects by ADB and USAID demonstrated sustainable models by establishing integrated value chains linking production, processing, storage, distribution, and export. KOICA and HDP projects strengthened institutional linkages and policy frameworks, while KOICA's model of combining "advanced" and "standardized" facility packages exemplified a demand-driven support approach.

- Empirical analysis of Korea's agricultural ODA in Central Asia indicated that it had a significant positive impact on the agricultural value-added of recipient countries and contributed to increasing Korea's agri-food exports to the region. This

provides strong evidence supporting the continuation of agricultural ODA in Central Asia.

- The farmer survey yielded the following key findings and implications:
  - Due to unstable power grids and frequent outages, low-power facility designs and battery/solar support systems are essential.
  - The most preferred type of facility was smart farming in Kyrgyzstan and Uzbekistan, while vinyl greenhouses were preferred in Tajikistan, implying that a phased smart farming approach suits the former two, while thermal-insulated and water-efficient models should be prioritized in the latter.
  - The primary barrier to facility adoption was high initial investment costs (83.5%). Glass and smart greenhouses were often considered "unaffordable" (33–41%).
  - Regarding policy priorities, Kyrgyz and Tajik respondents emphasized financial support (subsidies, low-interest loans), while Uzbek respondents prioritized market support (contract farming, buyer linkages).
  - Farmers across all countries identified strong training demand in pest control, operation & maintenance, and finance, suggesting these topics should be included in capacity-building programs.

- The analysis of adoption intention showed that perceived shortage of inputs had a negative effect, indicating that ODA programs should include supply chain and joint procurement support for fertilizers, films, and components. Awareness of climate crisis had a positive effect, implying the need to promote

facility agriculture as a climate adaptation measure. Farm income had a positive effect, while land size had a negative effect, suggesting that small and medium-sized farms are more receptive—hence, low-cost packages targeting smallholders should be prioritized. Strong willingness to participate in ODA projects suggests that pilot programs should first target these motivated groups, and then expand through demonstration effects.

- The expert survey provided additional insights:
  - Both domestic and local experts rated the region's electricity and internet infrastructure as below average, indicating the need for facility designs that consider power, irrigation, and communication bottlenecks.
  - Both groups identified high initial investment costs and lack of skilled personnel as the top obstacles, followed by inadequate infrastructure and weak policy support.
  - For ODA priorities, foreign experts ranked "PPP enhancement" first and "country-specific ICT/governance strategies" second, while Korean experts ranked "customized strategies" first, "crop-linked approaches" second, and PPP third, suggesting the importance of context-based strategic differentiation.
  - AHP results showed that Korean experts preferred a gradual advancement from vinyl to smart greenhouses with a focus on vegetables, whereas local experts prioritized specialty crops and preferred easily installable glass or vinyl greenhouses.

Recommendations for Central Asian Greenhouse Agriculture

- We suggest the vision for Central Asian greenhouse agriculture Official Development Assistance (ODA) as "constructing a low-energy, high-efficiency greenhouse agriculture ecosystem to enhance climate resilience and productivity in Central Asian agriculture." The three Central Asian countries face common structural vulnerabilities, including water scarcity, extreme weather and climate anomalies, soil degradation characterized by salinization and desertification, and shortages of specialists and skilled labor. Greenhouse agriculture is identified as a key solution to address these challenges and enhance agricultural sustainability.

- To realize this vision, we established three strategic objectives: ① constructing climate-adaptive production systems, ② creating market-linked high value-added, and ③ developing country-specific customised models; and three implementation foundation objectives: ④ achieving self-reliance in human and technical capacity, ⑤ diversifying development financing and activating public-private partnerships, and ⑥ establishing institutional and policy environments.

- Basic directions for achieving these objectives include: constructing climate-adaptive systems; strengthening water and energy efficiency; adopting integrated value chain approaches; promoting human and technical capacity self-reliance; expanding development financing and partnerships; and establishing country-specific strategies whilst strengthening institutional foundations.

- To operationalize these basic directions, six core tasks have been identified as detailed implementation strategies for greenhouse agriculture ODA in Central Asia.
  - First, climate-adaptive greenhouse technology dissemination employs a two-track approach combining appropriate technology with advanced systems, differentiated by country. Uzbekistan should develop three-tier technology models, diversify strategic crops (strawberries, shallots, herbs), and establish AKIS center as regional technology transfer hubs. Tajikistan should prioritize insulated, low-power systems and mini-greenhouses for winter production. Kyrgyzstan requires insulated plastic greenhouses with solar thermal storage suited to highland conditions.
  - Second, water management and irrigation efficiency should establish smart irrigation systems, renewable energy pumps, and ICT platforms across all three countries, with differentiated priorities: large-scale clusters for Uzbekistan, small-scale drip irrigation for Tajikistan, and cooperative-based systems for Kyrgyzstan.
  - Third, stakeholder capacity strengthening requires customized training by stakeholder group (policymakers, researchers, farmers, value chain actors) and digital knowledge platforms. This includes Korean training programs for officials, ToT programs and experimental greenhouses for researchers, farmer field schools for producers, and AI-enabled platforms developed with Korean ag-tech companies.
  - Fourth, production and distribution system advancement establishes Uzbekistan as the regional hub through cold storage centers, automated sorting systems, and processing facilities

with Korean company participation, with phased expansion to Tajikistan and Kyrgyzstan.

- Fifth, private sector engagement models include turnkey arrangements, joint ventures, public-private pilots, and competitive cooperation projects. Uzbekistan should focus on smart greenhouse complexes and export-linked clusters, whilst Tajikistan and Kyrgyzstan emphasize cooperative-based smallholder models.
- Sixth, institutional frameworks and implementation road maps prioritize technology financing and quality standardization in Uzbekistan, cooperative organization and data infrastructure in Kyrgyzstan, and streamlined permitting and master plan integration in Tajikistan. Common measures include policy training, institutional advisory services, and strengthened linkages between research, education, and knowledge dissemination.

Characteristics of fruit farmer's farm management structure and policy tasks responding to the internal and external changes

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Purpose of Research

- Rapid internal and external environmental changes such as climate change, the aging of farms, technological changes brought about by the Fourth Industrial Revolution, shifts in the distribution environment, and shifts in agricultural product consumption trends, are significantly impacting the entire fruit industry. Farms and other agricultural management entities are the primary actors responsible for responding to these internal and

external environmental changes. Therefore, analyzing the management structure of individual fruit farms is crucial to enhancing their ability to adapt to these changes and to identify support measures. This study aimed to analyze the relationships among farm management characteristics, management strategies, and performance by type of farm management structure, and to propose policy measures to strengthen farm management capabilities and enhance the competitiveness of the fruit industry.

Research Method

- This study targeted fruit farms, among horticultural agricultural producers sensitive to domestic and international environmental changes, who urgently need to strengthen their production and supply management capabilities due to the recent sharp decline in production and subsequent price surge. To understand the agricultural management structure of fruit farms in response to internal and external environmental changes, a survey was conducted with approximately 1,000 fruit farms (response rate 24.4%). The survey included agricultural management characteristics (farm income, management scale, management type, specialization, production method, distribution method, management strategy, management performance, etc.), awareness of external environmental factors (climate change, agricultural labor shortage, changes in distribution environment and consumption patterns), and agricultural management decision-making (decision-making methods, decision-making process, and outcomes). Analysis of variance and multivariate regression analysis were performed to identify characteristics of agricultural

management, management goals, and management performance by decision type in fruit farms.

Main Findings

- The types of agricultural management decisions made by orchard farmers in response to internal and external environmental changes are categorized into six types based on three criteria: decision-making method, decision importance, and decision-making outcome. Of these, the strategic decision-making type (SD) based on decision importance and the successful decision-making type (SuD) based on decision-making outcome were identified as the most desirable decision-making types. In other words, fruit farmers of the SD and SuD types actively respond to external environmental changes, establish management strategies accordingly, and utilize smart farm facilities to reduce the proportion of manual labor in the process of implementing these strategies. Furthermore, they show a tendency to increase agricultural income and investment in management performance. Furthermore, fruit farmers under 50 years of age, those with an agricultural income of KRW 100 million or more, and those with a management scale of 2 hectares or more primarily exhibit the strategic decision-making type (SD) and the successful decision-making type (SuD).

- While fruit farms are willing to adapt to changing external environmental conditions, the proportion of farms developing response plans is low. Younger farms are more likely to adopt production facilities and equipment to address climate change,

and to switch to new products and varieties. Furthermore, farms with higher annual agricultural income and larger operations are more likely to adopt new agricultural technologies to address climate change. Meanwhile, older farms are more likely to expand their use of agricultural machinery to address the shortage of agricultural labor. Although statistically insignificant, younger farms are more likely to expand smart farm facilities.

- Factors affecting the current agricultural income of orchard households include the household's age (-), part-time occupation (-), target for orchard management scale reduction (-), sales method diversification strategy, online transaction method, willingness to actively respond to agricultural labor shortage, establishment of strategies to respond to changes in the distribution/consumption environment, and awareness of government support policies.

Policy Suggestions

- To achieve the policy goal of enhancing the competitiveness of the fruit industry, policy support should be focused on fruit farms with desirable agricultural management structures, specifically SD and SuD farms. Specifically, policy support should be focused on those farms under 50 years of age, with an agricultural income of at least 100 million won, and with farms of at least 2 hectares.

- To enable individual orchard farmers to adapt to internal and external environmental changes and achieve their management goals, agricultural management support policies must focus on

strengthening their decision-making capabilities. The direction of agricultural management support policies for orchard farmers can be broadly divided into two areas. First, strengthening their capacity to adapt to internal and external environmental changes is crucial. This requires individual orchard farmers, as the main players in agricultural management, to recognize the impact and importance of these changes and proactively respond to them. Furthermore, support is needed to enable them to develop goals and strategies tailored to environmental changes through diverse data and information, as well as expert consulting. Policy initiatives to achieve this goal include enhancing agricultural management decision-making support systems, expanding programs to provide and share agricultural management-related information, expanding specialized technical education and training programs, and supporting financial and sales management programs.

- The second is to strengthen the agricultural management capabilities of individual fruit farmers. Support is needed to strengthen individual fruit farms' agricultural management capabilities so they can implement management strategies and achieve successful results. Policy initiatives to achieve this include joint response support through farmer organizations, support for the introduction of new technologies and varieties, support for the development of diverse processed foods, development and support of emergency response manuals, and support for individual farm management diagnostic programs.

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