Scientific activities responsible for successful forest greening in Korea

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ABSTRACT
Successful forest greening aligned with economic growth implemented by Korea is considered best practice in most developing countries. However, the specific technologies used for this greening process in Korea have been insufficiently described. In this study we extensively reviewed papers published in academic journals and related documents regarding greening projects. We identified significant contributions from five technological areas related to forest greening in accordance with policies: (1) forest survey and inventory; (2) tree improvement; (3) seeds and nurseries; (4) tree planting and tendering; and (5) forest pest control. In conclusion, the forest greening of Korea has been successfully achieved through a combination of investment in forest protection with a well-equipped technological base that has helped us select suitable species, prepare seedlings, and plant and nurture the trees properly. Meanwhile, we also found that official development assistance (ODA) from the international community contributed significantly to the greening activities of Korea to overcome technical and economic limitations. Thus, based on the successful example of forest greening in Korea, to restore degraded forests in developing countries a systemized ODA should be provided to support the development of a scientific and technological base for developing countries.

Introduction
Global environmental problems have been the principal concern of international communities since the Rio Declaration in 1992; in these circumstances, sustainable forest management is necessary as forests are an important factor in climate change adaptation and mitigation. In addition, as the elimination of poverty and hunger is an ultimate goal of the sustainable development goals (SDGs), there is a growing interest in international communities to provide a stable livelihood for rural and mountain communities. Forest greening is a prerequisite to reduce or eliminate flooding and/or landslides, which ultimately contributes to improvements in communities’ livelihoods.

The Food and Agriculture Organization (1982) cited Korea as the only country achieving successful forest greening and effective economic growth after World War II, and Brown (2006) has suggested that the successful greening of Korea be used as a suitable model of forest restoration for developing countries. As a result, more developing countries would like to implement the forest greening management and technology developed by Korea, especially in devastated mountain areas where previous reforestation efforts have been unsuccessful. However, in order to implement the successful story of forest greening accomplished in Korea in other developing countries, we need to provide a clearer explanation and more practical instructions about the best procedures to achieve a successful outcome.

Incidentally, after undergoing many trials and errors, we have come to realize that planting trees does not necessarily guarantee the successful establishment of forest. To establish a mature forest we need to adopt different approaches to nurture and tend the forest. Thus, through this study, we wanted to examine and identify the basic science and technologies that have significantly contributed to Korea’s successful greening and which would likely be conducive to facilitating forest greening programs in developing countries.

The Japanese occupation (1910–1945) and the Korean War (1950–1953) caused considerable devastation to Korean forests. The devastation was most severe in 1952 when the forest stock was estimated at just 10.5 m³/ha. Although Korea made efforts to protect and restore its forests, the forest stock remained at a plateau with little or no increase until 1972 (Bae et al. 2010). After the military regime took authority in 1961 the government prioritized forest greening and the Korea Forest Service (KFS) was established in 1967. However, the forest stock did not increase until 1972, despite the implementation of active forest restoration measures.

As mentioned by Bae et al. (2010), despite considerable efforts to rehabilitate forests after the Korean War, the forest stock in South Korea remained stagnant without any apparent change until the early 1970s. Thereafter, the turning point for a meaningful increase in forest stock appeared in 1973 (Figure 1). In Korea forest stock is calculated for trees > 6 cm in diameter at breast height (DBH, 1.3 m aboveground); it takes at least 5 years to reach this size, since the trees planted were relatively small (< 1 m high). Therefore, we can say that the establishment of the KFS in 1967 enhanced the forest stock volume visibly from 1973. Thus, it is possible to say that the increase of forest stock was not a result of the first 10-year forest greening plan that had begun in 1973 as mentioned by Lee (2013), but by previous initiatives of the KFS before the implementation of the greening plan. Lee (2013) identified the strong backing of the KFS by President Park as the most important factor in the greening program’s success. However, much change in forest stock had already occurred before the initiation of the first 10-year forest greening plan.
with the reorganization of KFS under the Ministry of Agriculture and Forestry. Therefore, strong leadership and administration restructuring were not the only factors positively affecting the forest rehabilitation and increase in forest stock in Korea.

The former prime minister, Mr. Goh, a working-level official in charge of the first 10-year forest greening plan in the Ministry of Home Affairs, acknowledged the use of forestry technology in successful greening (Lee et al. 2015). To examine the role of forest technology, Lee et al. (2015) analyzed a review of seven technology sectors that historically contributed to 70 years of forest greening in Korea. They categorized the sectors into 20 technologies in the fields of rehabilitation, seeds and nurseries, tree improvement, forest pest control, forest survey and resource management, wood utilization and fuel-wood plantation, and short-term income source development. The study carefully examined how these key technologies were prepared for greening in practice; however, it was insufficient to highlight how these technologies were applied in the process of forest greening in Korea.

In this study, we aimed to establish the hypothesis that a scientific and technological basis was used in successful forest greening in Korea. We looked closely at the contribution of science and technology to the forestry sector during the development of Korea’s greening policy, to ensure that the contribution of science and technology was the essential factor for the successful greening. If a list of core technologies for forest greening can be established, these technologies can be used in developing countries with devastated forests in sustainable greening programs through official development assistance (ODA). Therefore, this study was conducted to prove that Korea’s successful forest greening was based on a foundation of science and technology and to emphasize that we should transfer this scientific and technological basis to other developing countries to facilitate the success of their forest greening programs.

**Methods and materials**

Since most publications describing Korea’s successful forest greening to be focused on political and social factors, Lee et al. (2015) referred to additional scientific and technological factors. Based on the information described by Lee et al. (2015), we examined publications by the Forestry Academy Society and forest-related organizations to identify scientific and technological contributions that could enhance forest stocks. The time for the examination was different for each document but ended by 1987, when the second 10-year forest greening plan was completed earlier than initially planned.

**Literature and documents**

Since accomplishments in science and technology are initially identified through academic activities, we summarized the papers published from 1962 to 1987 in the Journal of Korean Forest Society (JKFS), a leading forestry academic association of Korea. In addition, we reviewed the projects conducted by the Forestry Experiment Station (FES), based on data from 1958 to 1987. With these, and reports prepared by the Special Forest Products Center of National Forestry Cooperatives Federation (NFCF), which implemented scientific and technological support projects, we screened the projects of forest greening conducted by the semi-public sector before 1987.

Preparing the data for analysis, we have extracted materials that have greening-related titles and keywords from papers in the JKFS and the related documents issued by the FES and NFCF. We closely looked into the abstracts of the extracted literature and examined whether they refer to greening-related technology or not. Whether the technology had been applied or not could be determined by their falling into one of the six categories explained in the “Data analysis” section.

**Data analysis**

Considering the seven fields mentioned in Lee et al. (2015): (1) rehabilitation technology; (2) seeds and nurseries; (3) tree improvement; (4) forest pest control; (5) forest survey and resources management; (6) wood utilization and fuel-wood plantation; and (7) development of short-term income sources, we examined the technical aspects associated either directly or indirectly with forest greening. We examined the possible contributions of science and technology to forest greening and how these were applied.
The aim of the present study is to ultimately determine some examples of science and technology that can be adopted to practically transfer to developing countries through ODA. We determined whether the fundamental research for forest restoration was conducted voluntarily and independently by the Korean government and researchers, or whether it was performed with the help of international communities such as ODA.

**Results**

The role of science and technology on successful forest greening from the publications in the Journal of Korean Forest Society

KFS is the biggest academic association in the Korean forest sector and was established about 10 years after the war in 1962 to develop scientific research. The society had played a significant role in extensively promoting the importance of forests. The second journal volume of KFS, published in 1962, covered the proposed installation of an administrative body to independently manage forest and water environments. This proposal provided the foundation for establishment of the KFS in 1967.

The KFS journal, then named *Forestry and Forest Science*, issued its first volume in 1962 and changed the name to *Journal of Korean Forestry Society* (JKFS) from the fifth volume. This is the oldest academic journal in Korea’s forestry sector and had issued 104 volumes by the end of 2015. The journal, which includes research and technological articles, has been the most important medium for academic exchanges within the discipline of forest science in Korea. According to KFS (2010), various papers, including those on forest products, were published until the early 1970s, and there was a significant increase in the number of papers on tree improvement from the early 1970s to the mid-1990s. Papers on the forest ecology were most common until the early 2000s, in line with research trends.

The proportion of sectoral papers for each period in the greening process indicates the changes and focus in forestry research over time (Table 1) that would have affected forest policies in Korea.

**The dawning period for greening (1962–1967)**

The first volume, published in 1962, carried papers on forest greening such as “On the rooting of the cuttings of two conifer species” written by Yim (1962), “A study on sprouting of a young merchantable pitch pine stand” by Park (1962), and “Timber survey” by Kim (1962). Out of 63 papers issued during this period, papers from the six areas included 14 on forest survey and inventory (22.2%), nine on seeds and nurseries (14.3%), six on plantations (9.5%), five on pest control (7.9%), and one on erosion...
control (1.6%), accounting for 55.6% of the total. It is especially notable that papers on forest survey and inventory, and seeds and nurseries, accounted for 36.5%, more than one-third of the total.

*The base-setting period for greening* (1968–1972)

A total of 59 papers were issued during this period, including eight on seeds and nurseries (13.6%), seven on pest control (11.9%), five on tree improvement (8.5%), four on inventory (6.8%), three on erosion control (5.1%), and one paper on plantations (1.7%). This indicates the changes in focus; the number of papers on inventory decreased, whereas those on seeds and nurseries, tree improvement, and pest control increased, accounting for more than one-third of the total. Therefore, the need for forest resources inventory and correct planting techniques were initially required, followed by tree improvement for actual planting. Meanwhile, the number of papers on forest policies, such as “The definition of forest” by Ji (1969), increased.

*The start-up period of greening* (1973–1978)

As academia became active, the journal published four times a year and issued 166 papers including 25 on seeds and nurseries (15.1%), 17 on erosion control (10.2%), 16 on tree improvement (9.6%), 12 on plantation (7.2%), nine on inventory (5.4%), and eight on pest control (4.8%). This showed further changes in focus. As the forest greening plan was being implemented, the focus on seeds and nurseries became one of the most important issues. However, the results also showed a significant increase in the awareness of the need for erosion control. However, papers on seeds and plant introduction, hybridization and selective breeding increased considerably, with other papers on tree physiology or forest ecology.

*The finish-up period of greening* (1979–1987)

As shown in the start-up period, papers on tree physiology/forest ecology and forest product processing occupied a large proportion of the total papers, and the proportion of forest greening papers decreased to one-third of the total. We identified the changes in research in high-quality forests in key areas, with 33 studies on seeds and nurseries (8.7%), 30 on plantations (7.9%), and 23 on tree improvements (6.1%) in this period.

Based on the two periods of development and implementation, the greening-related research was published primarily before the first 10-year forest greening plan started, and, in contrast, the number of relevant papers decreased during the implementation period (Figure 2). Given that the paper representation in the journal is delayed with respect to when the research was carried out, this finding implies that scientific and technological activities preceded the forest greening project.

*Scientific and technological activities in research reports during the greening period*

Unlike the papers in journals that were published after the research had been carried out, the research reports of project plans and programs were reported concomitant with the research. The FES was the only national research institute to conduct forest research in Korea. The FES was originally founded by the Japanese from 1922, and maintained by the Korean government until the end of the forest greening period (1987). We reviewed the research reports of the FES to understand the immediate focus of national forest rehabilitation.

Modern forest research in Korea was first performed in forest resource surveys implemented by the Japanese before the first forest law was promulgated in 1908. Forest inventories for the purpose of colonial exploitation policies were completed by 1910, which showed the forest stock of Korea as 102 m$^3$/ha. The first forest vegetation survey was performed in 1913, and the FES was established in 1922. The Japanese conducted several studies until the end of World War II in 1945 on seeds for planting, plantations, and pest control (Forestry Research Institute 2002). After liberation, Korea worked hard on developing its own forest research program, but was inhibited by the impact of the Korean War (1950–1953), and had to spend considerable time restoring the program.

The Forestry Research Institute (2002) divided its developing stages into three periods: (1) the warm-up period (1945–1956); (2) the dawning period (1957–1982); and (3) the settle-in period (1983–1990). Because there were little records of research projects before 1957, we could review the materials only from 1957. As done for the review of JKFS, we classified the period into four phases as follows: (1) dawning (1957–1966); (2) base-setting (1967–1972); (3) leap-up (1973–1978); and (4) settle-in (1979–1987). This was based on the development and growth of the FES and the establishment of the Forestry Administration (FOA). We considered that the first 10-year plan started in 1973 and the second 10-year plan started in 1979. Since the forestry research usually takes more than a year to complete, several projects were counted twice or more when we reviewed annual projects. Even though there was some duplication, the annual review
reasonably estimated the percentage changes of research projects for each sector.

The dawning period (1957–1966) represented a reorganization of the framework of forestry research in various fields. Research was associated primarily with forest rehabilitation, which accounted for more than two-thirds of the total projects during the period. The studies on forest surveys and inventories represent a small proportion of the total studies because the information is related only to tree inventories (Table 2). At the time, the forest resource survey was considered a survey project rather than a research project, and so was not included in the list of research projects. Therefore, we determined that the national forest research institute focused on developing the foundations for forest restoration.

The largest proportion of research (c. 25%) was on tree improvement research in this period, which was performed during the period. The studies on forest surveys and inventories represent a small proportion of the total studies because the information is related only to tree inventories (Table 2). At the time, the forest resource survey was considered a survey project rather than a research project, and so was not included in the list of research projects. Therefore, we determined that the national forest research institute focused on developing the foundations for forest restoration.

The largest proportion of research (c. 25%) was on tree improvement research in this period, which was performed continuously from the time of Japanese occupation. The studies reported that *Pinus rigida*, introduced from the USA, grew twice as quickly as the native Korean pine, *P. densiflora*. Based on this report, *P. rigida* was widely planted throughout the country. Based on the research of tree improvement, *P. rigida × taeda, Populus tomentiglandulosa*, and Italian poplar (*Populus euramericana*) were selected as suitable tree species for the early stage of forest greening. In addition, the research on seeds and nurseries, tree planting, and forest pest control accounted for 33% of the total projects, suggesting that Korea effectively determined suitable tree species and nurtured planted seedling growth. The information on forest resource surveys was not correctly represented in Table 2, which was confirmed by the Annual Report of Forest Resources Survey and Inventory Institute (1971) affiliated with the FES. The forest resource survey of 1959 was the first attempt at using a 1:50,000 topographical map of Gangwon-do and Gyeongsangbuk-do Provinces using aerial photographs from 1964 to 1968 (Table 3). Research using aerial photographs was conducted with the support of developed countries through the United Nations Special Fund, Counterpart Fund of the Korean government, and technical assistance from the Food and Agriculture Organization (FAO). The stock tables for major forest types were provided based on FAO standards through the project, and a forest survey manual was established, which provided the foundation for the current forest inventory manual (Kim and Kim et al. 2015).

The base-setting period (1967–1972) showed a similar pattern to the dawning period, but focused on the planning and preparation of the first forest greening plan. Studies in tree improvement consistently accounted for the highest proportion (152 projects, 29.9%). More than 50% of the studies focused on research providing the fundamentals of successful forest restoration with 48 projects in seeds and nurseries (9.4%), 46 in plantations (9.0%), and 39 in forest pest control (7.7%). Studies on erosion control were extensively conducted, focusing on N-fixing tree species and *Rhizobium*, which resulted in the practical application of science and technology in forest rehabilitation. In 1969, the Forest Resources Survey Inventory Institute (FRSII) was established as an affiliated institute of FES for the continuation of a UN–Korea forest research project that expired in 1968, and produced the first national forest survey in 1971 (Table 3). This first national forest survey was performed to determine basic statistical data by examining accurate stock volume and forest growth conditions to establish a master plan of forest rehabilitation for the first 10-year greening plan (from 1973 to 1982, completed early in 1978). The national forest soil survey and forest resources inventory were indispensable in developing the greening plan. Most forest-related ODA funds given to Korea were invested for the survey and inventory.

During the implementation of the first 10-year forest greening plan, referred to as the leap-up period (1973–1978), the proportion of research in seeds and nurseries decreased significantly.

### Table 2. Changes in research projects of the Forestry Experiment Station of Korea conducted before/during the period of forest rehabilitation.

| Period       | 1   | 2   | 3   | 4   | 5   | 6   | Subtotal | Others | Total |
|--------------|-----|-----|-----|-----|-----|-----|---------|--------|-------|
| 1957–1966    | 7   | 24  | 49  | 109 | 52  | 7   | 59      | 300    | 139   | 439   |
| 1967–1972    | 16  | 16  | 48  | 152 | 46  | 39  | 317     | 192    | 509   |
| 1973–1978    | 3.1%| 3.1%| 9.4%| 29.9%|9.0%|7.7%|62.3%     |37.7%   |
| 1979–1987    | 2.5%| 3.5%| 5.3%|34.0%|13.8%|10.4%|69.5%    |30.5%   |
| Total        | 1.1%|2.3%|4.7%|21.8%|15.3%|9.6%|54.9%    |45.1%   |

*Note: 1, forest survey and inventory; 2, erosion control and soil stabilization; 3, seeds and nurseries; 4, tree improvement; 5, tree planting and tendering; 6, forest pest control.*

### Table 3. Forest resources survey history of Korea during the start-up period for greening (1960–1992; modified from Kim and Kim et al. 2015).

| Year          | Summary of forest resources (conditions) survey |
|---------------|-----------------------------------------------|
| 1959          | The first attempt using 1:50,000 topographical map |
| 1960–1963     | National forest conditions survey (Forest Bureau of the Ministry of Agriculture and Forestry) |
| 1962–1964     | Private forest conditions survey (National Forestry Cooperatives Federation) |
| 1964          | The first national forestry statistics based on local surveys |
| 1964          | Agreement on project management plan for forest resources survey between the Ministry of Agriculture and UNDP–FAO |
| 1964          | Launch of UN–Korea forest research project agency |
| 1964–1968     | Forest research for Gangwon and Gyeongsangbuk regions (1.2 million ha, UN–Korea forest research project agency) |
| 1969–1971     | Forest research for Nakdong River (2.4 million ha, UN–Korea forest research project agency) |
| 1968–1973     | Forest research for three rivers – Anseongcheon, Dongjin, Sang-Ju cheon (0.27 million ha, UN–Korea forest research project agency) |
| 1969          | Launching the Forest Resources Survey and Inventory Institute under the control of Forestry Experiment Station of the KFS |
| 1971–1975     | The first national forest survey (Forest Resources Survey and Inventory Institute) |
| 1978–1981     | The second national forest survey (Forestry Experiment Station) |
| 1986–1992     | The third national forest survey (Forestry Experiment Station) |
(from 9.4% to 5.3%), whereas research in tree tendering increased. Studies on correct planting and layout still occupied a large proportion (34%) of the total research. Comparing the percentage of papers during the base-setting and the leap-up period, there was an increase in plantation (from 9.0% to 13.8%) and pest control (from 7.7% to 10.4%). This suggests that pertinent research was conducted to provide technologies for managing planted trees while plantation projects were being implemented. Meanwhile, the Yeongil Bay Erosion Control Project (1973), the most famous rehabilitation project in Korean forestry, introduced soil stabilization techniques and planting techniques; however, only limited academic records (such as in civil engineering documents) regarding these processes have been found. Therefore, soil stabilization techniques were applied in several different fields. It was confirmed that forest surveys and related basic technologies for forest restoration played important roles in supporting policies for forest rehabilitation. The second national forest survey, in 1978, aimed at identifying the condition of national forests to provide data for analyzing the performance of the first 10-year greening plan, and to fully prepare for the second 10-year greening plan (Kim and Kim et al. 2015).

The settle-in period (1979–1987) was the second 10-year greening plan. During this period, primary research focused on the processes after forest rehabilitation. Studies on forest greening accounted for 69.5% in the leap-up period, but decreased to 54.9% in this period, whereas the percentage of the other studies increased to 45.1%, compared to the previous 30.5%. Therefore, the combined percentage of the six focal areas fell, including the percentage of studies on tree improvement in relation to forest greening, from 34.0% to 21.8% (Table 2). Additionally, the third national forest survey began in 1986 to investigate the forest resource condition to enhance forest-related benefits beyond the forest greening (Kim and Kim et al. 2015). Science and technology were applied to provide a basis for policy implementation for sustainable forestry management.

**Extension services of scientific and technological achievements**

When the manual has been developed with the support of scientific and technological research, it should be practically applied in the field. The NFCF was involved in the technical support of pest control. In 1956, the NFCF developed the Special Forest Products Center (SFPC) to supply spawn for the cultivation of shiitake mushrooms (Lentinula edodes), and during this process contributed to forest rehabilitation. From 1956 to 1961, the SFPC produced and supplied a natural enemy (Beauveria bassiana) of the pine caterpillar (Dendrolimus spectabilis), based on scientific research. The center supplied 18,000–40,000 units by 1983, and developed an enhanced strain of B. bassiana to survive harsh weather conditions. The average success rate of hardened B. bassiana was 73.2%. The SFPC also greatly contributed to the control of other forest pests, such as the fall webworm (Hyphantria cunea) and other moths. In addition, SFPC produced and supplied N-fixing bacteria (Rhizobium spp.) of leguminous plants used as fertilizer trees; supply began at 6.2 tons in 1963 and increased to 10 tons per year in 1967 and 1968. As the forest greening policy was ongoing and successful, the demand decreased gradually and reduced to 0.4 tons in 1986. The increment of tree growth by the treatment of Rhizobium was 30%–40%. The SFPC technology considerably enhanced the early survival rate in infertile soil conditions (NFCF 2002).

**Discussion**

**Science and technology as a fundamental factor in forest rehabilitation**

Many countries have been developing afforestation programs, but few trees survive harsh and devastated conditions. The Republic of Korea has been actively engaged in forest greening activities for arid areas and devastated areas on the basis of its successful forest greening programs. Korea intends to help developing countries promote their own forest greening policies and to make them realize that forests are a source of life. Forests enhance people’s livelihoods through their sustainable management. However, many countries have experienced numerous investment failures, possibly from limited understanding of forest greening.

Kim and Bae et al. (2015) proposed capacity building for forest management staff, and preparation of socioeconomic conditions as the key factors for sustainable forest management. However, it is difficult to create these socioeconomic conditions in the short term (Bae et al. 2010). Nevertheless, the forest greening program of Korea was highly successful. Therefore, we determined which technologies contributed to this successful forest rehabilitation in Korea during the 1970s.

The science and technology in forestry has a very wide spectrum, from afforestation to growth and regeneration for enhancing forest-related benefits, genetics to tree improvement technologies for superior genotype, tree physiology to landscape ecology, and governance systems to human resource management. We focused on reviewing forest greening and selected six areas related to this as discussed above. Although it could not be confirmed that the six fields are necessary and sufficient conditions for forest restoration or greening, we can say that planting trees alone cannot fulfill forest rehabilitation. Because keeping trees alive is more important than just planting, we focused on the fields of science and technology for increasing the survival rate of trees, which ultimately contributed to the successful conservation and management of forests.

It is desirable to use indigenous plant species that are adapted to local conditions, but species with higher socioeconomic value could be used for sustainable forest management. Within an environment with degraded infertile soils, a scientific and schematic approach is necessary for effective afforestation. Korea experienced repeated failures in forest rehabilitation until the early 1960s, with ineffective systems and limited scientific research being implemented.

To avoid repeated failure, there should be systematic policies in place based on scientific results that can be practically applied. Korea identified infertile soil conditions using forest surveys and inventory, and selected tree species with high survival rates. It also developed a practical scheme to provide good seeds, seedlings, and plantings through forest seeds and nursery research. Additionally, private sectors were invited to take part in forest greening projects by utilizing techniques developed through the research. A good example would be the control of pine caterpillars with natural enemies and the provision of cultured N-fixing bacteria to increase soil
fertility. Research was practically applied, and ecological and sustainable forest management policies were maintained after successful forest rehabilitation.

The most famous forest greening model in Korea is the rehabilitation project at Yeongil-Bay, located on the eastern coast of the Korean peninsula with very steep slopes and shale soils. Because of the natural circumstances, we assumed that the technologies in erosion control and soil stabilization were very important for the project. However, we could not find clear scientific records documenting erosion control at the site. Therefore, the technology applied to the project might come from other sources.

Thus, it was inferred that the forest survey and inventory could be performed with help from international communities including the FAO as presented in Table 3, and the erosion control projects could be applied cooperatively with technology supported by civil engineering. In conclusion, it was confirmed that forest greening was accomplished with technology platforms for forest rehabilitation based on forest surveys or suitable tree preparation and sufficient investment for forest protection and tendering.

Voluntary activities and the role of international communities

As indicated before, successful Korean forest greening was achieved in synergy with competent forest policy implementation based on scientific knowledge. For the maturation of conditions and efficient implementation of forest greening projects, the Korean government’s efforts and assistance from international communities has been necessary. It should be noted that the timely support from ODA was indispensable, considering the difficulties of establishing a foundation of science and technology by developing countries.

FRSII (1968) described the following in the report for a forest survey: “Even though we fully recognized the need of forest soils survey, we were not able to afford to do. But finally, we were ready to do as a part of 5-year economic development plan.” It showed that investment in fundamental science and technology was part of the national economic development plan through international loans. Forest surveys, using aerial photographs conducted in 1958, were supported by a UN Special Fund Aid and the FAO’s technical cooperation. Of particular note in the preamble is the sentence: “Even though we fully recognized the need of forest soils research.” Since Korean scientists experienced difficulty in conducting research independently owing to lack of funds and technology, the extent of external support required was much greater. Sufficient support from international communities could produce successful rehabilitation programs when the needs of recipient countries are met. That is, knowledge sharing of appropriate technology by donor countries may result in a success story in the recipient countries.

This was the case of forest greening projects on arid areas and/or devastated regions conducted by Korea. Han et al. (2014) conducted a survey to monitor rehabilitation projects for combating desertification in Mongolia by 10 local governments and private organizations of Korea since 2000. Through the 6-month survey over 28 regions, they found that most projects failed, although they were conducted by Korean experts who had experienced successful forest greening in their own country. The major reason for failure in combating desertification was donor-centeredness of the rehabilitation projects without considering effective planting, and insufficient follow-ups. Most of the projects were conducted by foreign experts without considering the local conditions such as the climate, soils, indigenous species, and plantation technologies of Mongolia. Most of the projects did not focus on sustainability. However, the Green Belt project conducted since 2007 to combat desertification in Mongolia is showing very successful results. The Korean scientists started co-research with Mongolian scientists including co-design and technology transfer in the first year (2007). They have collaboratively worked together from 2008 to 2011, and they have improved the program after the interim evaluation in 2012 to proceed to a 10-year co-project. The current co-project is successful through the application of effective technologies including soil stabilization with sand fixation, and selection of appropriate plant species such as indigenous vegetation.

Conclusions

Moon (2012) mentioned that the green revolution of Korea, under a strong administrative leadership, was the result of collaborative efforts of both the forest and agricultural sectors through science and technology. He illustrated that successful forest greening provided stable agricultural bases in such a mountainous country as Korea. Forest greening could ultimately be the base of economic growth of Korea. However, it was accomplished over a long period of time. Korea has overcome numerous failures in forest greening through scientific and technological approaches. The five key findings for forest greening ascertained from the literature were as follows: (1) forest survey and inventory; (2) tree improvement; (3) seeds and nurseries; (4) tree planting and tendering; and (5) forest pest control. The technologies covering these processes preceded forestry policies, whereas the technology for forest protection contributed greatly to forest restoration coupled with cooperation with the private sector. In addition, we found that the forestry experts struggled to create appropriate conditions of forest rehabilitation due to technical and economic limits, which could be overcome by ODA from international communities.

In conclusion, science and technology as a basis of forest rehabilitation were fundamental for successful forest greening, accomplished by the support of international ODA. We recommend that developing countries initiating forestry greening projects should develop systematic policies, to include scientific and technological approaches, and consider the successful case of the Republic of Korea.

Disclosure statement

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