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Unsustainability Risk Causality in a Private Industrial Forest: An Institutional Analysis of Factors Affecting Stand Ecosystem Services in Kochi Prefecture, Japan

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Abstract: Much research in recent years has analyzed the ecosystem service aspect of forests, while highlighting the need for sustainable forests. Forest management mechanisms at an inter-institutional level in Japan have been identified to hinder the implementation of forest management that is focused on the equal production of ecosystem services. This study presents an institutional analysis of unsustainability risk causality in a private industrial forest in Kochi Prefecture, Japan, from an ecosystem perspective incorporating common ecosystem service hazards that affect the sustainability functions of forests. This was performed with the aim to offer a basis for a less complicated analysis of ecosystem service hazards in industrial forests and to provide causal clarity at different institution levels. It was found that due to Japan's systematic top-down forest management approach with the law at the top, vertical relationships cause direct and indirect negative horizontal relationships at each institutional level. To mitigate vertical and horizontal effects, institutional adaptions must be performed to address a combination of satisfier and hygiene factors. Under current conditions of non-enforceable forest policy, objectives and decisions regarding policy and management instruments at the national level must be integrated. This requires effective and adaptive multi-level institutional governance.

Keywords: ecosystem services; sustainability; private forest owner; SFM; Japan; Kochi Prefecture; institutional analysis; small scale forestry

1. Literature Review

Much research in forest management in recent years has focused on the application of sustainable forest management (SFM) into public policy aimed at the preservation of the Earth's forests [1,2]. Most forest goods and services are not marketable but are of essential value for sustaining human life. SFM targets environmental conservation and the sustainable production of wood and non-wood resources [3–5]. SFM provides an optimum balance of ecosystem services (also frequently referred to as environmental services) through a focus on multifunctionality, while mitigating the effects of climate change [6,7]. It is generally accepted that SFM has become an important key element towards sustainable development [8,9].

Much attention has been paid in Japan to improve the condition of industrial forests through the implementation of multifunctional forestry into local communities. As a result, the forestry industry and surrounding ecosystem management has become refined to: (1) understand the issues for local implementation, and improve the technological efficiency and international competitiveness of timber production from the planting stage to harvest; (2) improve communication and involvement of private

forest owners for stand access; (3) assess growth characteristics of forest areas in terms of long-term productivity; (4) improve legal frameworks including governmental support schemes, and introduce certification schemes for a fair and effective realization of multifunctional forests [10–13].

In Japan, wide areas of mountain forests lost their forest cover due to high utilization of wood during WW2. These areas were widely reforested as hinoki (*Chamaecyparis obtusa*) and sugi (*Cryptomeria japonica*) even-aged monoculture industrial forests during Japan's postwar reforestation project [14]. Such plantations, if viewed from an economic perspective, can be considered an effective return on investment. However, coniferous monocultures are reported to be coupled with powerful long-term threats to sustainability affecting ecosystem services [15]. Plantations, especially even-aged monocultures, sustain insufficient wildlife diversity, act as ideal habitats for rapid and difficult-to-control population increase of certain creatures, due to missing natural predators [16].

In the literature, forest ownership can be categorized into four classes: industrial, non-industrial, institutional and public classes [17]. Responses among these classes regarding economic objectives and institutional mechanisms to influence them can differ remarkably, with industrial and institutional owners usually operating towards profit maximization goals [18]. Ownership of nearly 80% of Japan's industrial forest is distributed among mainly non-agricultural small-scale private owners, which makes industrial forest ownership in Japan highly fragmented. Of the approximately 2.5 million private forest owners, close to 1.5 million owners each hold less than one hectare of forestland [19]. Therefore, the behavior of these forest owners plays a central role in sustaining forest ecosystem services [20] and in the SFM implementation efforts of the Japanese national government, in accordance with the sustainability criteria and indicators of the Montreal Process [21]. The Montreal Process is an international working group found in 1994, which targets the development and implementation of criteria and indicators for the conservation and sustainable management of forests in temperate and boreal regions. Japan is one of its twelve member states, which together account for circa 50% of the world's forests [22].

Institutional drivers influence the behavior of forest owners in regards to strategies that impact sustainability promoting criteria. Such drivers commonly include education, regulation, technical and management assistance, and financial incentives [23]. As forest regulation is not enforceable in Japan [24], subsidy schemes are currently the main instrument to motivate forest owners to engage in forest management activities that promote sustainability, and as a result, to increase access to private industrial forest by sharing the cost of timber production. However, such cost-sharing incentives are reported to have little impact on changing owner behavior, raising the question if financial incentives are an appropriate instrument for promoting SFM [25]. In the study site of Kochi Prefecture, the subsidy scheme for the revitalization of private industrial forest is used as such a monetary incentive to increase the access to private forest. Previous research has shown forestry subsidies seldom fulfill their economic and environmental objectives [26]. Forestry subsidies in Kochi Prefecture are no exception. Notably, large areas of Japanese red pine (*Pinus densiflora*) plantations show strong signs of degradation and damage of the forest ecosystem [27]. In addition, Kochi Prefecture has frequent reports of browsing incidents especially in newly planted industrial forests. Viewing planted industrial forests from an ecosystem perspective is a way of evaluating the causation of unsustainability risk as a whole, instead of focusing on specific forest functions.

Institutions are socially constructed rules and norms governing individual or group behaviors [28]. Institutional factors explicitly explain growth processes. North [29] demonstrates that institutional factors (e.g., rules, norms, habits etc.) can affect growth processes and explain differences across countries. Acemoglu and Robinson [30] explore development processes of several countries based on their institutional settings. The authors found that institutions could affect individuals, as well as organizations. Rodrik [31] provides similar results where institutions influence growth and development processes. According to Thornton et al. [32], institutional analysis is a helpful research method for improving entrepreneurial decisions. Researchers applying institutional analysis in entrepreneurship-related topics are numerous [33–35]. In addition, institutional analysis has also

been frequently applied in the field of construction management [36], nuclear disaster research [37], and water management [38]. In the field of forestry, institutional analysis studies can also be found. For instance, Primmer [39] conducted an institutional analysis of the integration of biodiversity conservation into forestry in Finland by combining policy implementation and organizational adaptation. Results indicate the necessity of combining these two traditionally segregated approaches. Caballero [40] conducted institutional analysis of community-based forest management in Galician. The results highlight the importance of communal forests in Galician. These previous studies have demonstrated the suitability of institutional analysis to identify causalities of certain issues showing interconnections of institutional factors while highlighting areas for adaptation of regulation.

In this paper, an institutional analysis of unsustainability risk causality in private industrial forest from an ecosystem perspective in Kochi Prefecture, Japan, is performed using common ecosystem service damage that affects the three main sustainability functions. Kami Forest Owners' Association (FOA) in Kami City was selected as the main FOA, as it is considered one of the most influential FOAs in Kochi Prefecture and even in the whole of Japan. Institutions refer to man-made rules used by agents at various levels when vertically interacting within systemic, environment related situations [41], which then horizontally affect forest owner behavior at each level. Looking at this vertical-horizontal relationship is a significant new step to observe how factors affect forest owner behavior. A growing number of researchers are particularly interested in the way institutions positively or negatively influence processes related to ecosystems [42,43]. Institutional analysis has not yet been conducted to identify unsustainability risk causality in private industrial forests in Japan. As forest management issues are complex in Japan and field operations do not operate with a clear long-term strategy [44], we believe that institutional analysis from an ecosystem perspective is a necessary and helpful way for the identification of factors responsible for this situation. Institutions need to be effective in preventing damage and destruction to common-pool goods and resources [45]. Therefore, the identified factors affecting sustainable growth and development at each institutional level in the study site will provide useful information for forest managers to improve management instruments and policies for long-term sustainable forestry in private industrial forests, offer a basis for a less complicated analysis of ecosystem service hazards and provide causal clarity at different institution levels.

2. Methods

This study espoused an inductive method and was conducted through a bottom-up approach. Specifically, an exploratory approach was applied to investigate institutional factors at national, prefectural and municipality levels that influence forest owner decisions and field operations, which as a result, influence the quality of ecosystem services produced in local forest management. Data were coded with institutional analysis, which was adopted based on the five components of institutional analysis by Hollingsworth [46] (Table 1), and combined with theoretical coding as the core process in a grounded theory approach [47,48]. Institutional analysis can be perceived as the analysis of stakeholders in the governmental sector, NGO, and private organizations that implement or support decisions that lie behind a policy. Deviation analysis was performed as an additional analysis to classify the factors contributing to ecosystem hazards and unsustainability risk at each respective institutional level. A similar approach was adopted by Rowlinson and Jia [36] to identify factors that contribute to proactive and reactive interventions of illness induced by heat in construction workers. Organizational mapping was employed for an ex-ante examination of the interrelationships of the actors responsible for policy implementation, and to additionally demonstrate the current flow of financial resources. In this additional step, we argue that the management of ecosystem services requires autonomy from national governmental planning, to be planned and conducted at local-level to reduce unsustainability risk. This argument is supported by previous research on the mechanisms hindering sustainable forest management in Japan, in which the authors conclude that under current

systematic conditions, long-term oriented sustainability strategies can only be implemented if Japan's forestry can stand on its own [44].

Table 1. The five components of institutional analysis by Hollingsworth [43].

Levels	Properties
Institutions	norms, rules, conventions, habits and values
Institutional arrangements	markets, states, corporate hierarchies, networks, associations, communities
Institutional sectors	financial system, system of education, business system, system of research
Organizations	
Outputs and performance	statutes, administrative decisions, the nature, quantity and the quality of industrial products, sectoral and societal performance

2.1. Collection of Data

Data were collected over the course of three years with the aim of developing sustainable forest management (SFM) in private industrial forests in Kochi Prefecture, Japan. Participants and informants in Japan included stakeholders from various forest management-related institutions and organizations at national, prefectural and municipality levels, as well as public and private foresters and practitioners, forest owners, forest and ecosystem researchers, and workers in the local wood industry in Steiermark, Austria, and Freiburg, Germany, who are fully or partly familiar with the current forest management situation in the study area. The stakeholders in Japan involved officials from national, prefectural and municipality governments, and forest owners, workers in FOA, forest management students, Environmental NGO representatives, environmental management researchers, and forest technicians in the study area. Of this stakeholder population, an SFM Committee was formed, which was involved at different stages of the process of the research. The members of this SFM Committee were representatives of the Prefectural Forestry Department, the Prefectural Forest Information and Technology Center, Kami Forest Owners' Association, and a forester from Austria with an advisory role for ecosystem service management. In addition to discussions in five committee meetings regarding site structure management and the improvement of ecosystem services, the main source of data was a law and policy analysis including subsidy schemes, as well as field notes on the wants, needs and opinions of stakeholders. In a two-day inter-institutional data protocol, 71 questionnaires were collected from stakeholders in Kochi prefecture with professions ranging from student of forest management and forest owner to chief of forest management in Kochi Prefecture.

The questionnaires included questions on perceptions about SFM as a concept and measures regarding effective local implementation, as well as possible short, mid, and long-term unsustainability risks of current management. Data from the questionnaires were separated to reveal quantitative and qualitative data, the latter, to act as a parameter for 13 follow-up semi-structured on-site interviews. These on-site interviews were conducted from April 2014 to March 2015 in six different predominantly cypress and cedar forest sites where clear-cuts and selective loggings had been performed, with forest workers and supervisors for the collection of more detailed information about ecosystem service damage causalities from where forest works are actually being performed. The on-site interviews involved questions on the procedures regarding stand selection, stand ecosystem evaluation, type of management and future site development. In addition to the two-day inter-institutional data protocol and the follow-up on-site interviews, a focus group discussion (FGD) of forest management experts was conducted in May 2016 to evaluate and discuss the systemic aspect of the Kochi Prefecture Subsidy Scheme for private forest for realizing diverse forest and sustainability from the viewpoint of SFM. In this FGD, focus was placed on the effectiveness of this subsidy scheme towards the realization of the forest sustainability goals of the National Biodiversity Strategy of Japan (NBSJ). Lastly, for data coordination purposes, the SFM Committee went on a field trip to Steiermark, Austria, to discuss with experienced Austrian private and public foresters the causality of ecosystem damage in the study area given the quantitative and qualitative data collected. This decision was made to obtain independent

feedback from forest managers from a country where private industrial forests are managed from an ecosystem perspective.

2.2. Data Analysis

Levels of actors were organized into five levels: National level, Prefectural level, Municipality level, Field operation level, and Ecosystem level, with the latter embodying a non-human actor, which develops its ecosystem as a result of site conditions and man-made interventions into the forest structure on the Field operation level. The ability of a forest to self-develop its ecosystem is the reason why the ecosystem level was added to the analysis. Structural and qualitative developments within the private industrial forest ecosystem impact the development of sustainable capital: natural capital [49], institutional capital (or cultivated capital) [50] and social overhead capital [51]. The collected data then underwent vertical and horizontal institutional analysis for each of the five factors in Table 1, for theoretical coding in the grounded theory approach [48]. Ongoing theoretical sampling was performed for constant comparison and for comparative analysis [52]. Theoretical sampling was conducted until theoretical saturation was reached. In this core stage of the grounded theory approach, memoing [47] was conducted to document theories and hypotheses by establishing interconnections among institutional factors [53]. Potential risk factors of ecosystem hazards at each of the levels were then identified through deviation analysis through the criteria and indicators of sustainable forest management as described by the SFM working group of The Montreal Process [21] as shown in Table 2. The risk factors identified through this analysis were then connected to the coded data through institutional analysis and discussed for verification of cause and effect in current stands where ecosystem damage was reported. The relationships of identified risk factors and causes and effects were organized through the grounded theory approach as described.

Table 2. Forest ecosystem sustainability criteria [21].

Variable	Criteria
Conservation of biological diversity	Ecosystem diversity; Species diversity; Genetic diversity
Maintenance of productive capacity of forest ecosystems	Forest land and net area of forest land available for wood production Stock and annual increment of tree species available for wood production Plantations of native and exotic species Annual harvest of wood products by volume and percentage of net growth or sustained yield Annual harvest of non-wood forest products
Maintenance of forest ecosystem health and vitality	Forest affected by biotic processes and agents Forest affected by abiotic agents
Conservation and maintenance of soil and water resources	Forest whose designation or land management focus is the protection of soil or water resources Forest management activities that meet management practices or legislation to protect soil resources Forest land with significant soil degradation Forest management activities that meet management practices or legislation to protect water resources Water bodies with significant change in physical, chemical or biological properties from reference conditions
Maintenance of forest contribution to global carbon cycles	Total forest ecosystem carbon pools and fluxes Total forest product carbon pools and fluxes Using forest biomass for energy instead of fossil fuels
Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies	Production and consumption Investment in the forest sector Employment and community needs Recreation and tourism Cultural, social and spiritual needs and values

Table 2. *Cont.*

Variable	Criteria
Legal, institutional and economic framework for forest conservation and sustainable management	Legislation and polices Cross-sectoral policy and program coordination Taxation and other economic strategies Clarity and security of land and resource tenure and property rights Enforcement of laws related to forests Programs, services and other resources Development and application of research and technologies Partnerships Public participation and conflict resolution Monitoring, assessment and reporting on progress

3. Results

Organizational process mapping in the form of a top-down macro/systems fund flow system among institutions is demonstrated in Figure 1. The forest owner plays a dependent role among five institutional levels being affected by decisions on each respective level. The effects of institutional factors are categorized as effects on ecosystem service performance and effects on the forest owner. The order of results is organized in a bottom-up pattern starting with factors at Ecosystem level as the location of creation of ecosystem service outputs and performance, and ending at the national level where national objectives for SFM are being initialized and transferred to the other institutional levels (Table 3).

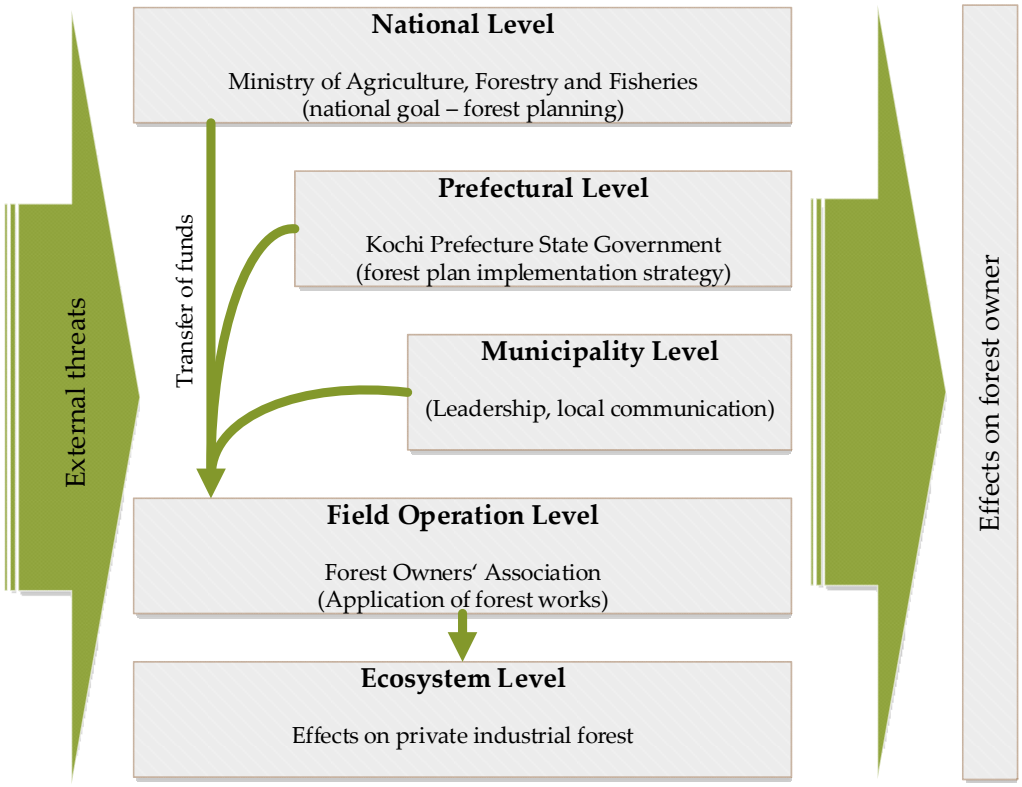

Figure 1. Forest management fund flow system (macro/systems level process map).

Table 3. Institutional factors affecting forest ecosystem and forest owner.

Institutional Level	Institutional Factors	Effect of Factor on Forest Ecosystem	Effect of Factor on Forest Owner
Ecosystem level	Site conditions	Understory and soil condition, site productivity	Alertness to on-site and off-site symptoms
	Stand structure	Vertical structures, stand density, species diversity, tree age distribution	
	Surrounding Ecosystems	Surrounding water bodies, natural forest	
Field operation level	Management system	Type(s) of available interventions	Characteristics of owner land use goals
	Thinning	Determinant of operation efficiency and international competitiveness	
	Stand assessment	Basis for type of management	
	Worker behavior	Influences quality of site related works	
	Technology access	Access to technical applications for ecosystem friendly on-site management	
	Non-value added activities	The types of activities within the supply chain that negatively affect value added of merchantable timber	
Municipality level	Leadership	Role in coordinating consensus among local stakeholders	Readiness
	Public behavior	Knowledge of SFM management of the public	
	Public involvement	Active involvement of the public in forest management related decision making	
	Owner integrity	Effort to integrate forest owners in management related decisions	
	Consensus building	Effort to balance local stakeholder forest wants and needs	
Prefectural level	Subsidy scheme	Characteristics of scheme to realize SFM and preserve ecosystem services	Owner response behavior towards financial support mechanisms
	Forest function integration	Integration of forest functions for ecosystem service preservation	
	Education and training	Industry and public knowledge regarding management strategies, technology and importance of preserving and enhancing ecosystem services	
National level	Policy and legislation	Access to private forest Ownership information Enforcement and penalties	Awareness of principles of SFM and forest ecosystem as determiner for self-action and risk perception
	Power of NGOs	Characteristics of policy	
	Forest planning	Description of biodiversity	
	Market structure	Conservation and maintenance of soil and water resources Status of NGOs in management decisions Top-down planning, forest segregation Foreign competition, Economy of scale	

3.1. Ecosystem Level

At the ecosystem level, factors that influence long-term sustainability of forest ecosystems include site conditions such as regional climate, pollution and soil condition, as well as the internal structure of the forests itself, which determines the growth pattern, stand structure, surrounding ecosystem, wildlife threat and climate change.

3.1.1. Site Conditions

Site conditions play an important role in the internal development of radial and vertical tree structures and shape the foundation for stable and vital forest. Forest degradation, mainly in unmanaged stands, was found to affect the condition of the forest floor, leading to erosion in Japanese cypress stands. This further associates unsustainability risk for forest degradation and landslides. A lack of communication and action to adequately mitigate and avoid a worsening

of site conditions at the ownership, municipality and prefectural levels is a sign for insufficient multi-stakeholder management.

3.1.2. Stand Structure

The major stakeholders at the level are identified as FOAs and the national forestry agency. However, with the trend going towards SFM, a conflict between management for production and management for ecosystem can be observed. FOAs, which are responsible for local on-site implementation of national forest management strategies, execute the ecosystem enhancement measures such as environmental thinning when access to financial support is provided; however, not with a long-term sustainability perspective in mind. At the end of a rotation period, a final clear-cut determines the temporary end of the forest ecosystem.

3.1.3. Surrounding Ecosystems

The quality of surrounding ecosystems, especially water bodies, is a direct indicator of the health of the forest ecosystem. Lack of supervision to evaluate environmental outputs of surrounding ecosystems on a regular basis associates with the risk of reaching "a point of no return" where mitigation would not bring sufficient improvement to both forest and its surrounding ecosystems.

3.2. Field Operation Level

At the field operation level, factors influencing sustainability by the implementation of on-site management include management systems, the cost of thinning operations, the assessment of the condition of the forest ecosystem, the skill of workers, access to technology and value-added activities.

3.2.1. Management System

FOAs currently execute mainly five types of management interventions in private industrial forests: strip thinning, selective thinning with and without extraction, clear-cutting and reforestation through the planting of new even-aged coniferous forest. Browse protectors are sometimes applied in areas with high browsing risk. The problem of these current management systems is that they do not offer forest owners ecosystem service-oriented alternatives to even-aged management such as uneven-aged permanent forest approaches. This is manifested in the attitude of FOAs to conduct management for profit maximization. Forest management is only carried out to gain access to subsidies, and mid- or long-term perspectives are not considered [44].

3.2.2. Thinning

Forest management interventions including thinning accumulate costs for the use of human and non-human resources on site. The cost of applying these resources is a determinant for efficiency and competitiveness of field operations. While topographical and road infrastructural factors also influence thinning costs due to different intervention complexity, it was identified that the cost of thinning is nearly double the cost of a clear-cut in the study site. This high cost shows the necessity of financial support to compensate for the cost of production cost and the actual monetary timber value. As man-made forest requires care in forest growth stages for ideal development of the forest ecosystem, thinning cannot be neglected. A breakdown of thinning costs is needed. Such transparency in how the cost for thinning is determined by FOAs provides detailed understanding for the practices necessary to lower these costs.

3.2.3. Stand Assessment

Assessment of forest condition is found to be focused on monetary rather than ecosystem values.

For example, FOAs provide an estimate of stand value based on tree size and quality criteria alone. An evaluation of the forest ecosystem is not performed, which could be used as a basis whether

management intervention is needed to improve ecosystem services. Human resources capable of administering ecosystem assessment under SFM sustainability criteria shape the basis for the mitigation of stand unsustainability risk.

3.2.4. Worker Behavior

The behavior of workers in applying on-site management has an impact on how much damage is caused during an intervention period. Effective skill is capable of minimizing the amount of stand damage, such as soil and stem damage, which directly contributes to the preservation of the forest ecosystem. It was found that workers implement operations and utilize machinery with sufficient care, which has kept intervention-related site damage to a minimum. This associates unsustainability risk causality with planning and strategy related factors at the respective national and prefectural levels.

3.2.5. Technology Access

The application of technology, especially heavy machinery such as harvesters and cable yarders, can influence the amount of damage caused to soil and the risk of damage to stem and understory vegetation. Certain soil damaging applications such as winches pull logs out of the stand, damaging the forest floor. A link between technology and ecosystem service damage is through the selection of harvesting technology that offers an unacceptable tradeoff between cost, profit and conservation, when other, more soil friendly technology is available.

3.2.6. Non-Value-Added Activities

Reasons for FOA higher thinning costs can be determined when discussing non-value-added activities at field operation levels, which cause an increase in operating costs. Value-added activities are activities within the supply chain of merchantable timber from stand to log processing that do not unnecessarily lower timber value when progressing among stages. Many non-value-added activities are associated with static, non-human related factors such as complex forest topography. Interviews with FOA officials and the Kochi Prefecture Forestry Division highlighted the problem of high thinning costs through non-value-added activities as a matter of concern. For instance, diameter at breast height limitation suggests maximum log diameters of approximately 35 cm. Larger diameters exceed the capacities of local sawmills although larger radial log dimensions possess higher volumes.

Another common non-value-added activity is the frequent moving of timber between harvesting sites, temporary and final stockyards and locations for further wood processing. This leads to two consequences. The first consequence is that managers at the field operation level tend to suggest and produce unsustainable forest structures that deliver as much wood per hectare as possible to reduce harvesting time and cost. The second consequence is that cost factors leave little room for producing more ecosystem effective diverse forest structures that incorporate broadleaf species for which a market is missing at the national level.

3.3. Municipality Level

Factors at the municipality level define resource management, which include leadership, public knowledge and involvement, owner integrity and consensus building.

3.3.1. Leadership

Unlike many nations In Europe where municipality governments guide the on-site management of forestry businesses, and the needs and wants of private forest owners to go in accordance with sustainability principles exists, such local leadership is currently not available in Kochi Prefecture. Yamaba and Nakagoshi [54] show the need for multi-stakeholder participation due to dynamics in the wood market, as well as policy development. A serious problem in Japan is the increasing loss of

interest of private forest owners in managing their forest land. Subsidies are no longer enough of an incentive for active participation in many areas [27,55].

Leadership shapes the priority of forest management implementation in the way resources are allocated from and to the forest site. For example, a forest-site-coordinator communicates the necessity of ways to enhance ecosystem services in a selected private industrial forest stand providing practical solutions for short-, mid- or long-term realization. Such leadership could be an effective way to gradually adapt the willingness of forest owners and FOA to rethink management objectives from profit maximization to ecosystem service maximization, similar as in the theory of Integrated Governance where practices need to be accomplished in order to develop a shared sustainable strategy [56].

3.3.2. Public Behavior

Public behavior influences the attitude of the public towards the management of forest. It can stimulate or enable the application of measures to mitigate the risks of ecosystem hazards. It describes the feeling and appreciation of an individual for the ecosystem services forests provide and the wish for its conservation. The fact that degrading forest sites, large areas of clear-cuts, and poor quality of water bodies are not generally recognized is a sign of lacking public behavior. Public behavior is important as a driver of forest ownership and the industry to steer management for the equal production of ecosystem services.

3.3.3. Public Involvement

Public involvement is the governmental acceptance and consideration of active public attitude in events of sensible hazards that may indicate damage or a neglect of one or more forest ecosystem services. Public involvement can range from individual reporting of hazards to relevant administrative offices, to public mobilization of resources for improvement or mitigation. Currently, public involvement can be observed in cases where waste can be found in forest but other ecosystem service conservation-related cases, which include forest structure related issues, are still uncommon. Public involvement can be utilized as a source of human resources for shaping local sustainability.

3.3.4. Owner Integrity

The forest owner is the fundamental stage of forest management. The attitude of the forest owner is in many cases conclusive of how forest structure is established and how its long-term management is applied. Owner integrity is the effort to involve the forest owner in forest management-related decisions. In the current system, most forest owners who do not wish to take part in the management of their forest are encouraged to temporarily transfer the rights for the management of their land to a local FOA. With a simple signature, the responsibility of forest owners to engage in management-related decisions is completely transferred to the FOA. Owner integrity is a necessary condition in which owners must be committed in the sustainable management of their forestland.

3.3.5. Consensus Building

Consensus building is needed when conflicts of opinion collide and hinder decision-making. However, consensus is necessary for the shaping of decisions that are in harmony with all relevant stakeholders. An example of insufficient consensus building is the effort of NGOs to improve the condition of river banks, which are part of forests in one area of the study site. In many cases, money could not be raised to address the identified ecosystem issues in these river banks unless they could be mitigated with currently available thinning subsidies. The systemic inflexibility regarding the consensus building for alternative forest management measures should be reconsidered to make sure ecosystem service management is not restricted to institutional factors.

3.4. Prefectural Level

At the Prefectural level, factors refer to issues related to the supply chain of the forestry industry and the preparation of management strategies for the implementation of SFM. These include the Kochi Prefecture subsidy scheme for private industrial forests, the integration of forest functions in decision-making processes regarding forest structure, and education and training in relation to SFM.

3.4.1. Subsidy Scheme

The Kochi subsidy scheme for private industrial forests is designed at a national level to realize national forestry objectives. Up to 72% of thinning costs are subsidized. This is a rate that is close to the average in Asia [57]. The problem in regards to the management of ecosystem services is that at such a relatively high rate, private forest owners are encouraged to maintain or afforest new areas of similar coniferous even-aged forest instead of forest with higher tree species diversity that possess more varieties of vertical structures. Currently, the subsidy scheme is necessary as a tool to create consensus among forest owners. Due to low roundwood prices, subsidies are needed to meet annual logging goals. Without these financial incentives, most forest owners would not engage in management. However, focus group discussions have revealed that excessive thinning at 30% intensity, as suggested by the subsidy scheme, may be counterproductive in the effort to design forests with higher species diversity.

3.4.2. Forest Function Integration

Forest function integration refers to management that focuses on all forest functions rather than on one exclusively in order to make sure that certain ecosystem services are not lost. Forest function segregation is observed in a variety of economic, logistic and socio-demographic stress conditions. Economic pressure occurs because of falling timber value, high extraction costs, rapidly rising demand of wood, forest areas that are difficult to access, demographic change, and forest owners not engaging in forest management. These five factors that often lead to a segregation of the management of forest functions are present in Kochi Prefecture. Focus group discussions showed that the above-mentioned subsidies do not contribute to multifunctional forestry, which would be an integrative approach. The terms multifunctionality and environmental preservation in the subsidy objective statements are too broad to be achieved by mainly thinning works.

3.4.3. Education and Training

Forest management education is still a lack of prospect, or lack of prospect opportunity in Kochi Prefecture. What reasons, other than profit are there to be or become a forest owner? What benefits, other than personal profit maximization are there that make it worth it to be or to become a forest owner? How can a forest owner be actively involved? How should FOAs change to provide more alternatives to even-aged forest management? Access to education that addresses these questions and that addresses alternative management opportunities may greatly increase reasons for forest owners to be actively involved in forest management. Content-based education with specific practical examples of the advantages of forest integration, and how to implement the concept of SFM for ecosystem service maximization in Kochi, can stimuli the interaction between the socio-cultural system and the forest ecosystem.

3.5. National Level

Factors identified at the national level include type of policy and legislation, power of non-governmental organizations, forest planning, societal culture and market structure.

3.5.1. Policy and Legislation

Forest laws and policies are important instruments for the local implementation of SFMs to maximize forest ecosystem services. An analysis of the Japan Forest and Forestry Basic Act has delivered insights to the strengths and weaknesses in regards to SFM implementation. The Japan Forest and Forestry Basic Act is aimed at the implementation of sustainable forestry in the prefectures of Japan [58]. It was found that the analyzed law:

(1) does not warrant access to private forests

In general, access to forests is necessary for the application of management. Without this access, factors contributing to the damage of many ecosystem services such as water purification, biotic diversity, or the production of high quality timber, cannot be mitigated, which may lead to degradation and long-term unsustainability.

(2) insufficiently describes the characteristics of forest ownership

Clear description of forest ownership is necessary for the identification 'when' and 'how' one becomes a forest owner. This includes forest area, species and location-related information, and information on how ownership should be treated in events where ownership is transferred to a third party or by inheritance. This conflict affects the assignment of manageable forest, especially in events when intervention is necessary to improve or mitigate the ecosystem aspect of forests.

(3) does not provide a benchmark for the enforcement and penalization of law violation

Forest laws have an equal effect on everyone in a society and are protected by law enforcement. Violation can or will result in legal action. A policy possesses less legal power than a law. The Japan Forest and Forestry Basic Act does not address the enforcement of forest law.

(4) shows characteristics of being a forest policy rather than law

Based on the key elements of forest law and forest policy model of Lindsay et al. [59], the Japan Forest and Forestry Basic Act did not meet the requirements for being a forest law with respect to two elements: Law enforceability and penalties, and explicit formulation [24].

(5) does not address the preservation of biodiversity

To address biodiversity, Japan has a separate law, the Basic Act on Biodiversity; however, biodiversity is a significant factor in forest ecosystem services and should be addressed in forest law in a specialized way.

(6) only briefly addresses the importance of conservation and maintenance of soil and water resources.

Water and soil condition influences the environmental productivity of stand and surrounding ecosystems. Soil erosion and a drop in water quality are direct results of insufficient soil and water conservation.

3.5.2. Power of NGOs

NGOs play an important role in balancing stakeholder wants and needs and in shaping the type of forest-structure-related management to ensure that focus on the production of ecosystem services remains in all forest functions. They provide sources to insight, research and expertise to enhance the forest ecosystem. A key factor for current ecosystem risks in Kochi private plantations is the lack of NGO power and NGO consultation. This can be explained in the one-sided approach of governmental bodies in implementing national and prefectural forest plans at local level. Governmental structures allow little room and resources for alternative management methods.

3.5.3. Forest Planning

Through Japan's Forest Planning System, forestry strategies planned at national, prefectural and municipality levels are implemented in private industrial forests. These plans are updated every five to fifteen years [12]. Forest planning focuses on even-aged monoculture management strategies that leave little acceptance for alternative management methods, which would involve stand structures

more capable of producing balanced ecosystem services. The ecosystem aspect of forest is mentioned, but the chances of improving ecosystem services by, for instance, increasing tree species diversity or introducing permanent forest concepts, for ensuring long-term sustainability, are not yet part of this system.

3.5.4. Market Structure

(1) Production and allocation inefficiency

A market is a place where supply and demand operate and where buyers and seller interact to trade goods and services. In Kochi, the production of wood in industrial forests is supported with public funding to compensate for high extraction costs. The production of the forest function recreation can be considered as low as monocultures do not create aesthetic incentives for a visit. In addition, access to private industrial forests is restricted. In comparison, in many European nations, recreation is a free accessible, non-rivalrous public good and not a club good as in Kochi. Due to the even-aged, monoculture structure of industrial forests, the production of most public goods is low. Carbon storage is very high but nondynamic due to an even-aged forestry approach.

(2) Monopoly

In Japan, the majority of forest work is conducted by FOAs, which have no obligation to maximize value-added timber [44]. Only a very small portion of work is conducted by self-administered management by forest owners or small private businesses. This centralized monopoly structure allows FOAs to set prices for forest work relatively effortlessly.

(3) Missing markets

Markets for broadleaf timber are still widely undeveloped in Japan. Work that involves broadleaf timber extraction can insufficiently be compensated for by the sale of broadleaf wood. Markets for broadleaf timber fail to form due to a focus on coniferous species.

(4) Incomplete market

Production of roundwood in even-aged coniferous monocultures is considered the most cost-efficient approach in forest management. However, production in even-aged coniferous monocultures fails to take into consideration the negative effects of this approach on passively related third-parties, and the environment, which are indirectly affected. Many public goods of forests are produced inefficiently (lack of public goods) and may cause environmental damage and unbalance as spillover effects. The market fails to prevent these spillover effects.

3.6. Effects on Forest Owner

At the horizontal level, decisions influencing forest owner behavior include alertness to on-site and off-site symptoms, the characteristics of land use goals, readiness, owner response behavior towards financial support mechanisms, and the awareness of principles of SFM and forest ecosystem as determinants of self-action and risk perception.

3.6.1. Alertness to On-Site and Off-Site Symptoms

Knowledge incorporates all the different factors of the ecosystem aspect of forests from functions, biodiversity, carbon sequestration, water purification, etc. This knowledge provides the forest owner with awareness to be and stay alert for making responsible and timely decisions regarding sustainable forest establishment, structure and management. Alertness is active attention by sensory awareness. Alertness includes qualities of being observant to on-site and off-site symptoms, and the preparedness to respond in a timely manner.

Interviews revealed that even the fundamental multifunctional role of a forest as an ecosystem service provider was not widely known among owners. Some owners interpreted the cause of low or damaged forest ecosystem services solely to the lack of thinning. Without adequate education and training available, answers indicate that current knowledge was likely accumulated through experience, or from other sources at the municipal and prefectural level.

3.6.2. Characteristics of Owner Land Use Goals

Personal goals at the ownership level are a driver to invest in stand management to reach a certain desired output. Whilst there are many different attitudes of forest owners ranging from passive and active managers to profit maximization and recreation focused managers, two main characteristics of forest owners were identified: managers for profit maximization and passive managers who want to keep their forest but not be involved in management decisions. This finding relates to ecosystem services that forest managers with an environmental focus provide important facilitation in applying management approaches that target the preservation of ecosystem services.

3.6.3. Readiness

Readiness is the preparedness and prompt willingness to engage in management activities when it becomes necessary to preserve the forest ecosystem. Readiness is an important factor for timely response to prevent mid- and long-term hazards. The main factor held accountable for lack of readiness is unsatisfactory profitability of timber. Although financial incentives can improve the readiness of forest owners, self-motivation, which is not solely based on economic output but also ecosystem factors, needs to be acquired through education at the municipality and prefectural levels and through a more precise ecosystem approach in general at the field operation level, which is stimulated on the national and prefectural levels.

3.6.4. Owner Response Behavior towards Financial Support Mechanisms

Financial incentives through the subsidy scheme shape the attitude regarding forest management approaches shifting personal priorities. In many cases, introducing financial incentives for public forest management projects, as frequently executed by the Japanese forest planning system, bring about a mere "purchasing" of forest owner participation. This problem has been observed in previous research [60]. In addition, agreement to transfer authority to the forest planning system further distances private forest owner management involvement. These types of one-time agreements are not designed for a long-term relationship, and interest shown by forest owners is in most cases simply for the present moment.

3.6.5. Awareness of Principles of SFM and Forest Ecosystem as Determinants of Self-Action and Risk Perception

Interviews with forest owners revealed that the risks of ecosystem hazards through even-aged coniferous monoculture approaches are underestimated. Almost all forest owners favored an economy-focused approach with the typical homogeneous plantation forest arguing that regular thinning alone would mitigate unsustainability risks. Some forest owners argued that environmental preservation of forest would be necessary but did not characterize species diversity as a factor of lower risk. This indicates that studies on risk perception of forest owners should distinguish the impact of different mono- and multi-species approaches.

3.7. External Threats

3.7.1. Societal Change

The population of Japan is expected to decrease by approximately twenty million until 2050. This decrease in population is likely going to affect domestic wood demand, unless the resource wood will find new and alternative ways of utilization. Overstock may become a problem of industrial forest in the future. A decreasing need for management that involves timber extraction may conflict with the need for management for conserving and maintaining these ecosystems. In addition, the forest owner population in Japan is ageing fast [61]. An ageing forest owner population is associated with the problem of forest owners switching attitudes from active and passive management, with the latter being more interested in third party management, rather that self-determined management practices.

3.7.2. Wildlife Threat

Wildlife damage is identified in the form of deer browsing. Although mitigation measures have been introduced to decimate the deer population and to protect especially young trees from browsing damage, damage is still being reported. A focus group strengthened the need for introducing natural ways of dealing with browsing: "renewal thinning with followed natural rejuvenation can lead to increased food availability, and as a result, reduce young tree damage by browsing".

3.7.3. Climate Change

Long-term increases in climatic heat and a change in precipitation patterns are often considered effects that can lead to a shift in site conditions which can change the growth characteristics and growth requirements of certain tree species. A mixing of tree species and introducing alternative tree species are considered ways to enhance forest stability and vitality, mitigating the unsustainability risk climate change may pass.

4. Discussion and Conclusions

The analysis presented in this paper identifies institutional factors that affect the ecosystem performance and forest owner behavior at five levels: the Ecosystem level, Field operation level, Municipality level, Prefectural level, and National level in the study site Kochi Prefecture, Japan. The existing literature assumes that hierarchical structures can influence stakeholder behavior, as suggested by Rowlinson and Jia [36], who found that institutional causal factors could interact with each other and do not necessarily translate through the path of the system hierarchy. This study supports findings that factors cascade down the hierarchies of stakeholders, and additionally identifies a vertical and horizontal relationship.

Due to Japan's systematic top-down forest management approach with the law in the top, vertical relationships cause direct and indirect negative horizontal relationships at each institutional level. A key issue identified in this analysis is the impact of unenforceable forest law at lower institutional levels, and the forest owner. This is particularly important in terms of dealing with decision-making processes that involve private forest owners and their motivation in engaging in management. Japanese forest law describes a vision, but it does not formulate nor implement strategies in the form of enforceable regulations. Ota [58] claims in his study on Japanese forest law and policy that Japanese forest policy is mainly responsible for the current sustainability issues due to its limitation in effectively acting as a framework for implementation of SFM at the field operation level. Top-down planning is less successful than incorporating users of common-pool resources in system developments that match the ecological system on site, and the actions, norms and long-term welfare of its stakeholders [62].

Negative horizontal relationships have various effects on the forest owner: little alertness to on-site and off-site symptoms due to lack of awareness of SFM and ecosystem principles, management for profit maximization, and passive management through a system of transfer of ownership rights. These effects affect self-motivation and long-term commitment of the forest owner as they further distance forest owners from playing an active role in management decisions.

As observed in the analyses, the reason for the lack of long-term participation is rarely due to lack of capital, but instead lack of available information on market opportunities, access to silvicultural technology, forest law development, and taxation support. Investments that could have been made by private forest owners themselves with proper advice and guidance are lost with one-time management agreements [63]. Increased awareness of the principles of forest ecosystems by forest owners through sustainability education, can act as an institutional driver for self-action and better risk perception, which may improve the status quo of not engaging in management.

Participation and integration of forest owners is vital at all analyzed institutional levels. Readiness, as part of owner behavior, can be positively influenced by alteration of institutional drivers. The two-factor theory of Herzberg [64] is considered relevant in this issue as institutional drivers can

increase satisfaction but also decrease dissatisfaction for SFM. Satisfier factors (e.g., advancement, sense of responsibility and recognition, personal growth) increase the individual's motivation to engage, while hygiene factors (e.g., policies and rules, relations, compensation, working conditions) decrease the individual's dissatisfaction to engage.

Therefore, to mitigate vertical and horizontal effects on the sustainability of industrial forest, institutional adaptions must be performed to address a combination of satisfier and hygiene factors.

First, more SFM criteria and indicators of the Montreal Process [21] need to be addressed in detail and implemented in the Japanese forest law.

Second, forest law must be enforced to allow managers at the prefectural, municipal and field operation level to gain unrestricted access to private forests, and to make clear the responsibility of private owners to be actively involved in management decisions. To foster integrity, forest owner involvement in management decisions should be encouraged by institutional drivers at the prefectural and municipal levels, such as access to market opportunities, and applicable financial support for management interventions that are in the public interest. Involvement of owners in decision-making processes can stimulate networking among owners, which is consistent with research conducted by Boon and Meilby [65]. Such networks initiate synergy effects which have the potential to spread knowledge and expertise, and which have an educational effect on individuals not directly involved in environment related issues.

Third, to improve coordination of stakeholder opinion, the implementation of a forester system into legal structures should be considered. As results show, local stakeholders, especially forest owners are the key to implementing sustainability related objectives. Policies and financial support systems need to incorporate local stakeholder communication to determine whether decisions are appropriate for the target environment [66]. Evidence exists that local communities are capable of governing local resources sustainably [62]. Findings indicate that the homogeneity of tree plantations and their potential negative effects on the production of natural and man-made capital must be reevaluated, and proper mediation between private and non-private stakeholders through a forester system can play an important role in this process, a result consistent with recent studies [67,68].

Fourth, the financial support system of Kochi Prefecture needs to be redesigned. A subsidy scheme that encourages owners to transfer their management rights to a third party that is neither interested nor capable of assessing forest ecosystem condition, should not be considered a sustainable management strategy, as it further distances the public from active involvement in environment related issues. A new scheme should allow the establishment of multi-species forest to improve the production of ecosystem services. Subsidies with the aim of environmental development must not be restricted to forest age, to avoid excessive clear-cutting. Detailed description of subsidy objectives and subsidy schemes designed to meet the unique diverse characteristics of local forests will be vital in this approach. Research in Sweden has shown, for instance, that relative to spruce monocultures, mixed stands with broadleaf species performed better in terms of biodiversity, recreational and esthetic values, water quality, economic flexibility, and addressed risks associated with anthropogenic climate change [69].

It can be argued that under current conditions of non-enforceable forest policy, objectives and decisions regarding policy and management instruments made at the national level must integrate as they can influence agents vertically and horizontally. This requires effective and adaptive multi-level institutional governance by providing the resources and necessary freedom for assessment and application of site-specific management at the field operation level. The prefectural and municipal levels hereby need to ensure adequate coordination of these resources while providing institutional drivers in the form of education, market opportunities and stakeholder coordination to effectively steer and improve owner behavior in regards to engaging in sustainable management. In a system of unenforceable forest law, such stakeholder coordination would be impossible to realize under leadership with arbitration capability. Leadership through mediation by ecosystem experts at the

prefectural and municipal levels may be an effective possibility to generate long-term decisions, as called for by previous researchers [44].

However, institutions are not static but evolve based on human and social interaction affected by: human behavior, growth, development, consumption, demand, distribution and other change bringing factors [70]. The interaction of institutions is a dynamic, precisely interconnected, efficient and self-improving process. A change at any institutional level will affect the efficiency of the entire process [71]. Therefore, promoting a sudden change of ecosystem service policy at national level can affect horizontal and vertical interaction at all other institutional levels, if institutions have not been adequately prepared for the change. Capability of a timely acceptable balancing of the process will be crucial to maintain efficiency. As ecosystem service policy targets the increased production of mainly the non-commodity goods and services of ecosystems, it can be argued that for this balancing, first, an institutional environment needs to be created that agrees to the necessity of the production of these goods. Then, institutional drivers such as policy, implementation strategy and adequate incentives and support should follow for uncomplicated implementation. This is especially important for forest owners in the current case, as the vertical institutional influence at the identified different levels can result in conflict between individual practices of these owners and the common good [72]. Forest owners play a central and determining role in the current institutional environment. To be successful, forest owners will need support to adapt to it [46].

The results of this study can help determinate causal factors to identify the accountability of stakeholders and opportunities to take action for the improvement of forest management. Existing forest management research does not recognize the current forest management problem of Japan systematically, nor the institutional interrelationship of factors associated with it. This study collected data in Kochi Prefecture, Japan. The region-specific sample is a limitation of this study; however, the data could represent the situation of Japan as a whole, due to policy and subsidy systems being similar, leading to comparable perceptions of forest owners. This study also compares Japanese forest management with other European countries. In future research, studies on sustainable forest management in Japan should focus on cross-national comparison studies, specifically the coordination and leadership aspect of private forest owners at the prefectural and municipality levels from a long-term forest ecosystem perspective.

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