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Sector-wide social impact scoping of agrivoltaic systems: A case study in Japan

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ABSTRACT

The recent rapid promotion of renewable energy technology (RET) worldwide may have led to a greater social impact on local communities, where multiple otherwise-small individual units of RET are concentrated in one place, as may occur in the case of small photovoltaic power generating units, for example. This study examines such a case of the dissemination of innovative agrivoltaic systems (AVSs), a system in which photovoltaic power facilities are installed above cultivated farmland, across Japanese rural areas.

The paper offers a preliminary sector-wide social impact scoping (SSIS) for potential cumulative social impact of a dissemination policy of AVSs. AVSs were predicted to positively impact many local stakeholders. It was found that AVSs themselves improve energy security as they are, but if particular devices are accommodated, energy security is further improved. Several measures, including providing information to farm operators regarding specific examples of favourable economic outcomes and good agricultural practices, are recommended to mitigate any negative impact of AVS installation.

Policymakers should undertake SSIS for RET to reveal the variety of views among otherwise reticent stakeholders so that they can eventually increase the positive impact and mitigate the negative impact of RET.

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1. Introduction

Internationally, renewable energy technology (RET) has tended to receive a favourable reception because of its mitigating effects on carbon dioxide and energy security. On the other hand, there have been numerous cases of objections to RET raised by local people [1,2]. In Japan, RET has been accepted in general, but local communities sometimes have given mixed evaluations. The negative impacts perceived by local citizens have included safety concerns regarding the installation of RET facilities, the environmental burden to the locality including landscape changes, and risks to local industries and the local economy. In a study from Japan concerning geothermal energy initiatives, Kubota et al. [3] concluded that the reason for opposition to planned construction was uncertainty about the reversibility and predictability of adverse effects on hot springs and other underground features due to geothermal power production and the effect of heated water on reservoirs.

Larger-sized interventions, such as the construction of large dams, have been assessed by social impact assessment (SIA) [4], as such projects were believed to have a larger scale of social impact than other projects. Social impact is defined as the effect on the people involved due to change, that is, 'the real and perceived impact experienced by humans (at individual and higher aggregation levels)', caused by biophysical and/or social change processes generated by planned interventions [5]. Social impact assessment (SIA) requires quality engagement, achieved by examining comprehensive social impact, predicted or perceived by all relevant stakeholders, and securing procedural fairness by reflecting those opinions in the actual decision making relevant to the interventions concerned [6].

RET normally involves interventions that may have smaller-scale social impact than those potentially generated through larger-sized interventions. However, the recent rapid promotion of RET worldwide may lead to greater social impact on local

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communities, where multiple otherwise-small individual units of RET are concentrated in one place, as may occur, for example, in the case of a concentration of small photovoltaic power (PV) generating units. Irie and Kawahara [7] have reported that, while local people perceived social benefits regarding PV installations in general, a concentration of PVs was perceived to have a negative local impact. In recent years, perceived negative impact concerning PV installations have sometimes led to court cases in Japan. As an example, in 2012, residents of an area where PV installation had occurred requested that the solar panels be removed and made a claim for damages to the interrupted tranquillity of their daily life [8]. Even a small number of PV facilities may sometimes generate perceived negative impact for local landscapes. For example, there is an area in Japan where local citizens have themselves created regulations restricting the installation of PVs on roofs to conserve traditional landscapes.

A current issue is that RET has rarely been assessed by means of SIAs. SIAs conducted for energy systems so far have included mines, oil and gas, hydropower [9] and other large energy projects while few SIAs have been conducted for RET. Many RET projects have been limited in scale and number, involving a single unit in some cases, and their introduction has been perceived as only a minor intervention. This situation explains why SIAs, in relation to RET, have often been considered less relevant than those for larger energy projects. However, it is just as important for project promoters to seek to obtain local trust for RETs as it is for larger energy projects [10].

This paper discusses sector-wide social impact scoping (SSIS), which incorporates the initial phases of SIA to scope the general sector-wide cumulative impact of RET and analyses factors that are clues to how positive impact could be enhanced and negative impact mitigated. The first and second phases of SIA involve social impact scoping through enabling the various stakeholders to participate in dialogue, identifying potential social impacts including risks perceived or predicted by those various stakeholders in a comprehensive manner, clarifying these impacts to each stakeholder as much as possible, examining requirements for acceptance of the interventions to proceed, and devising any measures to increase positive impact and mitigate negative impact [6].

This study applied the SSIS method to installing innovative agrivoltaic systems (AVS) across Japanese rural areas. The AVS is a system in which PV facilities are installed above cultivated farmland, with the same land yielding both PV power and crops. An AVS is one of several novel RETs introduced into Japan in recent years. The dissemination of AVSs needs to be investigated and managed properly because the AVS is a novel technology that employs novel systems, which may substantially change rural land usage. It also involves technically-related risks in its functioning not only for installers but also for local communities located near sites of introduced AVSs. This implies that AVS installation requires discussions concerning social rights and issues arising from its communal social acceptance, given the existence of risks in relation to local communities. The SSIS method can identify the various social impact perspectives of local stakeholders.

There has been little social impact assessed in Japanese impact assessments, not only in cases of RET installation but also for any type of general intervention, which leads to few social aspects being included in policy [11]. While internationally, SIAs have been undertaken usually through implementing extensive focus group meetings and group discussions among stakeholders, such procedures have rarely been followed in Japan. If focus group meetings and group discussions in SIAs were undertaken, it is likely that Japanese people would remain uncommunicative in public even though they may be opposed to particular interventions [12], which could lessen the value of SIAs. Considering that many types of RETs have been introduced recently that potentially require SIAs, SIA procedures need to be devised to lower the hurdle of implementing SIAs in Japan. SSIS can include questionnaires to address the psychological hurdles for stakeholders reticent to articulate opinions, and although the assessment costs are relatively low, it has proven to be effective in scoping social impact.

This study also illustrates that the application of SSIS may lead to multiple private sector proponents collaborating to develop industrial strategies to enhance or mitigate the current and potential impacts of their industry. This contrasts with project-level SIA that is conducted to inform decisions on a specific project. SSIS was conducted by ‘Zenkoku Einogata Hatsuden Kyokai’ (hereafter, Kyokai) [13], an association dedicated to raising awareness of AVSs and furthering AVS dissemination. Kyokai has twenty-one private sector member companies that sell PVs domestically. To the best of the authors' knowledge, this SSIS is the first substantive form of an SIA conducted by a private sector member-based Japanese organisation, although it is partial because only the first and second phases of an SIA were conducted (as explained in section 3 of this paper).

2. The Japanese context with regard to SIA and AVSs

The limited treatment of social aspects within impact assessments worldwide [6,14] has been especially obvious in Japan, not only regarding RETs but also for other projects. The Japanese Environmental Impact Assessment (EIA) Law, enacted in 1997, mainly concerns assessments pertaining to biophysical changes, and it only requires a limited-scope assessment concerning social effects, including changes in landscape and transportation. The EIA Law does not prescribe social impact analyses of projects that include any consideration of potentially affected stakeholders' perceptions and possible changes in their overall welfare arising from the projects [11].

The Japanese government has a target of achieving 22–24% of electricity generated from renewable energy sources (hereafter, RE electricity) in 2030. The percentage had attained 14.3% (4.7% after excluding hydro-electric power) in 2015, which means that RE electricity generation needs to undergo a significant increase by 2030. The government plans to increase PV generation from 23.71 GW in 2015 to 64 GW in 2030, involving 2.7 times more PV-generated electricity over this period [15]. The Feed-In-Tariff (hereafter, FIT) system, which is a country-wide support system for RE electricity dissemination, was introduced into Japan in July 2012. The FIT system enables a recovery of investment in RE electricity production within 10–20 years, through setting the price of RE electricity at fixed unit prices for 10–20 years. After the FIT system was implemented, businesses began installing RETs, such as photovoltaic panels (PVs) and biomass power, in the course of managing their assets. Further, the installation of PV facilities, which are easily attached to roofs even by private citizens, has increased rapidly (T. Shiobara, personal communication, 18 February 2017).

The boom in PV installation led to their installation not only on roofs, but also on landscapes, including farmlands. Initially, applications to public administration authorities for permission to install PV panels on land through the conversion of farmlands to non-farmlands increased rapidly after the FIT was introduced (T. Shiobara, personal communication, 18 February 2017). Increasing conversion of farmlands could potentially reduce Japanese farmland areas and agricultural production could potentially diminish, leading in turn to a further decrease in the self-sufficiency rate for agricultural products. The Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF) thus introduced regulations to restrict PV

Fig. 1. AVS example (An AVS on a Japanese tea farm plot in Shizuoka prefecture, Japan). Reference: Zenkoku Einogata Hatsuden Kyokai (2017) http://farmsolar.or.jp/.

installations through farmland conversion by allowing PV installations above farmlands only when farming would be continued where PV panels were to be installed [16]. Effectively, it was a regulation that only allowed AVSs to be installed as long as PVs would be set up on the farmlands in question.

AVSs are ‘mixed systems associating solar panels and crops at the same time on the same land area’ [17]. There are two types of AVSs: the monopole-type and the roof-type [18]. Most AVSs are currently roof-type. There is no regulation concerning the targets regarding either AVS type (Kyokai, personal communication, 16 November 2018) (Fig. 1). The logic behind AVSs is that many crops do not require 100% of solar insolation where it is produced; well-designed AVSs allow at least 80% of the usual agricultural production even with the shade produced by solar panels above the farmland, and crops preferring shade can even achieve higher productivity under the shade of AVSs [17]. Kyokai argued that, in general for PV generation through AVSs, a 20-year wait was not required to recover costs, which became an incentive for AVS installers to participate in FIT. AVS is currently the only licensed RE electricity generation system that utilises arable farming plots in Japan. Within the agricultural sector, there have been anecdotal suggestions to the effect that electricity income through AVS installation would benefit AVS installers, namely farm operators,[1] through providing a stable income for farm operators, who otherwise could only earn an unstable income from agricultural products, as well as maintaining agricultural development. Moreover, it has also been argued that when PVs have been installed above farmland where farming is occurring, the farmland can be effectively utilised for producing both agricultural products and energy [17,19,20]. As there is comparatively abundant land in rural areas [21], it has been further contended that AVSs could become a promising RE electricity source in Japan where there is a scarcity in available land resources.

On the other hand, the dissemination of AVSs has been a cause of contention within the rural sector, including among farmers, agricultural industry employees, relevant public administration authorities, and local residents. While farm operators engaged in installing AVSs have been willing to undertake this work, other possible negative effects have been identified, including: (1) environmental and neighbourhood amenity risks, comprising landscape degradation, sunlight reflection, radio waves, property damage from falling snow, noise and vibration during installation; and (2) agricultural risks, including loss of agricultural lands, interference with agricultural work, and a decrease in agricultural production due to shade [8,16,18,22]. There has also been concern that PV installation may spur agricultural land conversion given the weakness of the agricultural economy in Japan [23]. It has also been argued among local residents that the flexibility of land usage would be impaired by long-term installation of PV facilities on farmlands. However, to the best of the authors' knowledge, within the limited global literature on AVSs [17,19,20,22,24], very little research has been conducted on the social impact of AVSs internationally and in Japan [25].

3. Overview of sector-wide social impact scoping (SSIS)

International standard SIAs comprise four phases [26]: understanding the issues; predicting likely impact; developing and implementing strategies; and designing and implementing monitoring programs. SSIS incorporates the first two phases of SIAs (Fig. 2).

3.1. Understanding the issues

This phase analyses the issues identified through a literature review and exploratory interviews.

3.1.1. Methodology

A thorough literature review and seven exploratory interviews (Table 1) were conducted from October 2016 to January 2017 to ensure interviewers understood the issues correctly and to make sure that as many potentially relevant stakeholders as possible were identified before undertaking the subsequent stakeholder interviews in the second phase. Therefore, the aim was to understand the following issues: problems in agricultural sectors; regulatory, technical and economic viability of AVS; various potential positive and negative social impacts of AVS; and relevant stakeholders of AVS. The interviews involved two central government officials responsible for dealing with renewable energy and farming land policy matters, two municipality officials responsible for renewable energy and farming land policy in the study area, two local energy industry residents, and Kyokai. The interviews were either conducted face-to-face or by telephone, with interviews lasting from 9 to 155 min. After conducting the literature review and exploratory interviews, Kyokai sent several emails with the goal of understanding technical issues.

3.1.2. Results

Demographic analyses of Japanese rural sectors have highlighted the agricultural problems of decreasing population and an aging society, caused by long-term industrial transformation, and the diminished position of agriculture within the overall economy. Farm operators' incomes haves decreased as the rates of return within the Japanese agricultural sector have declined, due to lower prices for agricultural products; in turn, the amount of abandoned farmland has steadily increased. There has been considerable literature produced analysing Japanese agricultural policy, but comparatively little research conducted on farm operators' preferences towards agricultural policies.

Although many RETs have only been introduced in certain environmental locations, AVSs can technically be installed almost anywhere in Japan except where very strong typhoons are likely to strike or where snow is prevalent because sufficient sunlight is needed for operation (T. Shiobara, personal communication, 6 December 2017). The potential changes caused by the introduction

[1] Farm operators included other types of land users and farm operators who, despite not being farmers, engaged in farming work.

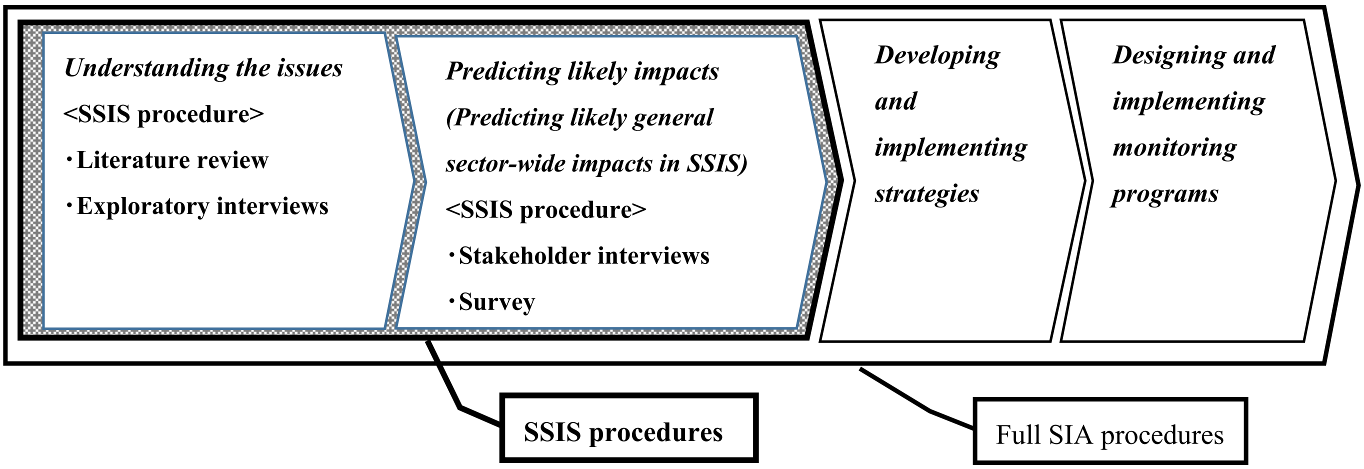

Fig. 2. SSIS procedures.

Table 1
Exploratory interviews.

Interviewees (number of people)	Month/Year	Minutes	Method
Central government officials (two)	Oct/2016	10,15	Telephone
Municipality officials (two)	Oct/2016	9,15	Face-to-face
Local energy industry residents (two)	Jan/2017	45	Face-to-face
Kyokai (one)	Oct/2016	155	Face-to-face

Questions
Q1. What are the significant problems in agricultural sectors? Are there effective ways to address such problems?
Q2. Are AVSs regulatory and are they technically and economically viable?
Q3. What potential positive or negative social impacts do stakeholders expect AVSs to have?
Q4. Who are the relevant stakeholders of AVSs?

of AVSs can occur in agricultural production landscapes, rental/purchase/sale prices of farmlands, and off-farm incomes. PV installation above farmland involves reducing the farmland available for farming use, potentially inconveniencing those working on the farmland and reducing solar radiation owing to the construction of pillars for PV panels. These changes may lower the unit amount of crop production for some crops and lead to a consequent reduction of farmland value. A MAFF regulation (2013) requires AVSs not to be introduced into areas where they could negatively affect land values or the efficient use of farmlands surrounding them. If AVSs are installed in compliance with this regulation, then neither the efficient use of farmlands nor the land's liquidity, whether by renting or purchasing, should be hampered [16,17,22,23]. The extent to which AVSs may reduce unit crop production depends on the crops concerned, the percentage of light interception due to the PV panels of the AVSs, and the types of farming regions, and it appears difficult to predict with accuracy the effect of these factors in combination on every crop cultivated in every type of AVS [17].

When PVs have been installed on farmland by farm operators and through agriculture-related industries and their power sold to electricity companies, the stable income outside farming for the farm operators increases. This result may indirectly lead to the promotion of agricultural production because it may prevent farm closures due to low farming income [25]. Increases in agricultural production and off-farm income may also lead to further changes in farmland prices and land values. This secondary effect might in turn induce higher-order changes [5], including helping to ensure the continuation of farming, as existing farmers become less inclined to leave farming and new farmers become more willing to take up farming, and a greater self-sufficiency in foodstuffs. MAFF regards the introduction of RET as important because it promotes the development of local agriculture, forestry, and fisheries, increases agricultural sector incomes, and promotes renewable energy that revitalises rural areas [27]. There are actual cases where the agricultural sector was developed by the usage of RET, such as when the increased operational cost of agricultural drainage, partly caused by The Great East Japan Earthquake, was supplemented by increased income from selling PV electricity [28].

The main stakeholders involved with AVSs, apart from Kyokai, were identified as farm operators who had installed AVSs, farm operators who had not installed AVSs, those employed in the agricultural sector, and local residents. Local residents were further classified into residents living near and those living far from farm land.

3.2. Predicting potential general impacts

This phase is the core phase of SSIS, which aims to predict sector-wide general impacts of AVSs. Impacts of AVS installation are different depending on the AVS systems and agricultural products that are cultivated under AVS solar panels. Therefore, specific impacts of AVSs are unable to be generalised. Therefore, while the phase of predicting impacts in full SIAs usually involve predicting the concrete impact of a particular large project, SSIS aims to predict the general impacts of policies - an AVS installation policy in this case.

3.2.1. Stakeholder interviews

The aim of the stakeholder interviews was to extract various types of AVS impacts as comprehensively as possible to be able to inform respondents in the subsequent survey phase so that they could evaluate AVSs with more information.

3.2.1.1. Methodology. Stakeholder interviews [29] (Table 2) were conducted, referencing the impact scoping methods used by Vanclay [30], to scope all the potential relevant expected impacts of AVSs for stakeholders as comprehensively as possible. Interviews regarding potential positive and negative impacts of AVSs were conducted by Kyokai and expert interviewers from October 2016 to March 2017 with the stakeholders identified in the first phase. Interviews were conducted after a short explanation of the aim of the interviews, including the neutrality of the research and the anonymous treatment of the interviewees' statements, with the aim of

Table 2
Stakeholder interviews.

Questions Interviewees (number of people)	Month/Year	Minutes	Method
Q1. What are the potential merits and demerits of introducing AVSs in your farm land?			
Farm operators who have installed AVSs (four)	Feb/2017	50,60,60,127	Face-to-face
Farm operators who have not installed AVSs (five)	Jan-Feb/2017	65,90,98	Face-to-face
	Feb/2017	11,32	Telephone
Q2. What are the potential merits and demerits of introducing AVSs for your work community?			
Workers in the agricultural sector (six)	Oct/2016-Feb/2017	30,45,70,90	Face-to-face
	Oct/2016, Feb/2017	17,20	Telephone
Q3. What are the potential merits and demerits of introducing AVSs for your residential community?			
Residents (five of seven live near farm lands while two live far)	Jan-Feb/2017	60,60,65,130	Face-to-face
	Mar/2017	50,56,60	Telephone

ensuring stakeholders would express their true opinions and feelings during the interviews. For the interviews to be neutral and the questions to be consistent among the different interviewees, the interviews were conducted under the condition that expert interviewers with no stake in the AVS industry, were involved. Most (15 out of 22) interviews were face-to-face and in-depth; the remaining seven were short interviews to supplement the in-depth ones. As the proportion of farm operators who had introduced AVSs was small and the recruitment of such interviewees difficult, all interviews involving them were conducted using snowball sampling. The selection of other interviewees was based on whether they knew about AVS-related issues well enough to extract various social impacts; they were selected partly through snowball sampling and partly by personal requests to participate.

After the explanation of the aim of this research, questions were asked regarding whether respondents knew about AVS and a brief explanation of AVS was provided if they were unaware of its meaning. Then, open questions were asked regarding potential positive and negative aspects of AVS for themselves or their community. The interviews were recorded with the interviewees' permission, and transcripts were made. The transcripts were double checked by another interviewer who did not conduct the interviews. Answers were clear, regarding which positive or negative impacts would be generated from each type of AVS, and there were no occurrences in which it might be unclear as to whether the impacts would be positive or negative. After the transcripts were made, the merits (positive impacts) and demerits (negative impacts) of AVSs predicted by stakeholders were listed.

3.2.1.2. Results. A summary of the results is shown in Table 3. Various social impacts following the installation of AVSs were identified. There was quite a difference between the social impacts perceived by farm operators who had already introduced AVSs and those who had not. All the farm operators who had already introduced AVSs felt, overall, that the impact had been more positive than negative for them, including the positive impact of stable income and maintaining steady agricultural production due to electricity selling. Since farming is heavy work, many of these interviewees had considered abandoning their farmland without the further incentives of the additional income that would arise from the selling of AVS-generated electricity. Income from electricity generation sufficed to compensate for demanding farming work and added further satisfaction because farmlands could be conserved. They did not regard AVSs as an obstacle to farm work; on the contrary, they considered AVSs capable of providing additional benefits as support structures, effectively helping them grow their crops.

On the other hand, those farm operators who had not introduced AVSs perceived an overall negative potential impact for themselves, principally in economic terms. In addition, they had concerns over the reduced flexibility of farmland usage, including inconveniencing farm work and crop selection and necessitating continual farming for at least 10 or 20 more years to recover the cost of an AVS investment. This reduction in the flexibility of farmland usage is common in most countries. In many types of RET globally, conflicts between renewable energy usage and local land usage have been discussed. For example, conflicts between the installation of geothermal energy facilities and land usage by the tourism industry have arisen in Iceland, a leading country in renewable energy [31,32].

The interviews of those employed in the broad agricultural sector (agriculture-related industries, associations, and public administrations) identified two principal issues: whether AVSs would have a beneficial impact for the farm operators with whom they corroborated, and whether AVSs would have a beneficial impact on their local areas, the global environment, and future generations. Many of them perceived the former potential impact would be negative whereas the latter impact would be positive. In terms of the impact on farm operators, they felt there were economic risks, since the selling price of PV power in the FIT system was rapidly decreasing, and technical risks since the flexibility of farming work and farmland productivity might be worsened by AVSs. Some also expressed the view that compliance with AVS regulations would be burdensome. In terms of a more general impact, some felt there might be positive impacts due to AVSs, arising from the clean-energy generation of electricity and the promotion of local employment, industrial development, and farmland conservation.

Local residents also predicted positive and negative impacts on farm operators, local areas, the global environment, and future generations. They felt that AVSs might have a positive economic impact on farm operators selling PV power, but also that there were economic risks to introducing AVSs that apply novel technologies. Some city residents also felt that there could be negative impacts on the rural landscape, as it would be disfigured with the intrusion of exotic AVS facilities and sunlight reflection. However, in general, local residents expressed limited concern over a negative landscape impact and felt there would be a positive impact in terms of efficient land utilisation, revitalisation of the local economy, and clean electricity generation replacing fossil fuel energy.

3.2.2. Survey

The aim of the survey was to predict the overall general impact of AVS installation as perceived by different stakeholders, the reasons for their predicting such impact, and how positive impact could be enhanced and negative impact mitigated in a sector-wide manner. The survey could enable evaluation of AVSs amongst a

Table 3
AVSs' impact identified from stakeholder interviews.

Impacts of AVSs (number of people)	Positive/Negative	Type of impact
Farm operators who have installed AVSs (four)		
Can earn income by selling electricity (four)	Positive	Economic
Can actively utilise farmland (three)	Positive	Economic
Effective use of AVS facilities for better agricultural practices (two)	Positive	Economic
Treatment to meet regulations is cumbersome (two)	Negative	Implemental
Farm operators who have not installed AVSs (five)		
Initial investment is a hurdle (three)	Negative	Economic
May have unexpected cost or demerits (two)	Negative	Economic
Can earn income by selling electricity (two)	Positive	Economic
Limited options for crop production (two)	Negative	Implemental
Necessity of continuing agricultural practices (two)	Negative	Implemental
Tend not to be earnest in the production of crops (two)	Negative	Environmental/Implemental
Those employed in the agricultural sector (six)		
Can earn income by selling electricity (three)	Positive	Economic
Produce clean electricity as alternative to fossil fuels (three)	Positive	Environmental/Energy security
Limited options for crop production. Unexpected effect (two)	Negative	Implemental/Economic
Initial investment is a hurdle (two)	Negative	Economic
Reduction of crop production or quality caused by reduced sunlight (two)	Negative	Economic
Treatment to meet regulations is cumbersome (two)	Negative	Implemental
May have abnormalities or failures of AVSs (two)	Negative	Economic
Local employment and industrial development (two)	Positive	Economic
Conservation of farmland (two)	Positive	Economic/Environmental
Residents living near farmlands (five)		
Degraded landscape (five)	Negative	Environmental
May have unexpected cost or demerits (four)	Negative	Economic
Dazzling caused by reflected sunlight (three)	Negative	Environmental
Can actively and flexibly utilise farmland (three)	Positive	Implemental
Produce clean electricity as alternative to fossil fuels (three)	Positive	Environmental/Energy security
Temperature increase in the neighbourhood (three)	Negative	Environmental
Can not flexibly utilise farmland (three)	Negative	Implemental
Initial investment is a hurdle (two)	Negative	Economic
Limited options for crop production. (two)	Negative	Implemental
Can earn income by selling electricity (two)	Positive	Economic
No effect in conserving energy (two)	Negative	Environmental
Residents living far from farmlands (two)		
Can earn income by selling electricity (two)	Positive	Economic
Initial investment is a hurdle (two)	Negative	Economic
Reduction of crop production or quality caused by reduced sunlight (two)	Negative	Economic

Only opinions that were made by more than one person are presented.

large number of stakeholders, which would be difficult to achieve by interview only.

3.2.2.1. Methodology. It was necessary to ensure the questionnaire designed for the survey was easily understandable and sufficiently concise, since it would be administered to individuals, for whom being questioned about social impact would likely be a novel experience. In terms of individual-level potential impact, AVS would only be perceived by farm operators, who would have actually introduced them, and it was generally predicted that only farm operators, who would predict overall positive impact from AVS installation, would install AVS. Therefore, SSIS was supposed to be relevant only to farm operators who felt there would be an overall positive impact. Accordingly, the research questions regarding farm operators' perceived individual impacts were as follows (Table 7): 1) How many farm operators may be interested in installing AVSs? 2) What are the characteristics/factors related to the prediction of an overall positive impact? 3) Are there specific negative impacts predicted by farmers predicting an overall positive impact? 4) How could a positive impact be enhanced and a negative impact mitigated (if and how could each characteristic/factor related to different stakeholders' evaluations be changed to generate better impacts)?

On the other hand, local community, global, and future generational levels of impact would potentially be predicted by all members of the community. When considering this point, the research questions on local community, global, and future generational levels of impact were as follows (Tables 8 and 9): 1) How many stakeholders in the local community predict more positive than negative impacts from the installation of AVSs? Is AVS generally acceptable to local people? 2) What are the characteristics/factors related to different stakeholders' positive evaluations regarding an overall impact? 3) How might a positive impact be enhanced and a negative impact mitigated (whether and how could each characteristic/factor related to different stakeholders' evaluations be changed to generate better impacts)?

The self-completion questionnaire (Appendix) began with a general explanation of AVSs and Japanese AVS regulations, including images of AVSs, and then presented opinions on the advantages and disadvantages of AVSs derived from four stakeholder groups: farm operators who had introduced AVSs, farm operators who had not introduced AVSs, those employed in the agricultural sector, and local residents. The stakeholder opinions were presented as comprehensively as possible so that the variety of opinions was well represented in the questionnaire.

For an evaluation of AVSs, the questionnaire's main questions (Table 4) concerned overall impact and type of impact, including economy, flexibility of implementation,[2] energy security, and environment, all of which were the most significant social impacts

[2] Flexibility of implementation was defined as flexibility of crop production and land usage, the necessity of continuing farm work, compliance with AVS regulations, and reporting to public administration officials.

Table 4
Key questions regarding positive/negative impact of AVS.

Questions to farm operators
It has been assumed that AVSs would be installed in your farmland where crops that fit with AVS technologies can be produced and where there would be no problems regarding further expansion of farmland, with the condition that there would be no subsidies provided for AVS installation, and that all the electricity generated would be sold to electricity companies.
In such a case, do you expect a positive or negative impact **personally** in terms of the following points?
< Very negative impact to Very positive impact >
• Overall
• In economic terms
• In terms of implemental flexibility
* Flexibility of crop production or land usage, or necessity of continuing agricultural production or obligation to abide by agricultural regulations and report to the government
• In environmental terms
Questions to all respondents
It has been assumed that AVSs would be installed in your local areas where crops that fit with AVS technologies can be produced and where there would be no problems regarding further expansion of farmland, with the condition that there would be no subsidies provided for AVS installation, and that all the electricity generated would be sold to electricity companies.
In such a case, do you expect a positive or negative impact **for your local community** in terms of the following points?
In such a case, do you expect a positive or negative impact **for the global environment and future generations** in terms of the following points?
< Very negative impact to Very positive impact >
• Overall
• In economic terms
• In terms of implemental flexibility
* Flexibility of crop production or land usage, or necessity of continuing agricultural production or obligation to abide by agricultural regulations and report to the government
• In terms of energy security
• In environmental terms

in relation to AVSs identified in the qualitative interviews. Energy security impact was not included in the questionnaire presented to farm operators as there was no such impact predicted by them in the stakeholder interviews. In the question concerning the overall impact of AVSs on farm operators, the following assumption was introduced: 'It has been assumed that AVSs would be installed in your farmland where crops that fit in with AVS technologies can be produced and where there would be no problems regarding further expansion of farmland, with the condition that there would be no subsidies provided for AVS installation, and that all the electricity generated would be sold to electricity companies'. The question was then asked regarding whether the respondent would expect a good impact or an adverse impact from AVS installation. Similar questions were posed to all stakeholder groups regarding the overall impact of AVSs at the local community, global, and future generational levels. Detailed, specific impacts were not articulated in the main questions as each type of AVS system at each location was regarded to have slightly different kinds of impact; for example, some crops cultivated in some areas did not require much sunlight and were not predicted to lower production under AVS, which could lead to less negative economic impact. It was also predicted that distinct types of impact due to AVSs would be identified as they affected concerned persons, local areas, the overall country, or other countries and regions, such as Asia, as well as global and future generational levels of impact. However, because of page constraints exercised in preparing the questionnaire, only questions directed at assessing impact at personal, local, global, and future generational levels were asked as those levels were considered of greatest pertinence to the respondents. To analyse the impact as indicated by the various groups and the differences in perceived potential impact by people with different values, questions regarding socio-demographic variables (SDVs), including income, job, sex, age, and the respondents' values and knowledge, such as their environmental concerns or knowledge of RETs, were included. In addition, the extent to which respondents felt that it was meaningful to conduct this questionnaire survey to examine the social impact of AVS dissemination was also posed.

An internet survey was conducted in March 2017 by a professional survey company (INTAGE Research Inc.) (see Appendix). A total of 514 complete responses (Table 5) from across Japan were collected, using stratified random sampling, to understand the opinions of the main stakeholders, including 153 farm operators, 153 employees from the agricultural sector, and 208 local residents (104 residents with farming plots within 500 metres of their houses and 104 residents living more than 500 metres from farming plots). The response rate was 65.8%.

3.2.2.2. Results. A summary of the results is given in Fig. 3 and Table 6. The results were generally consistent with the results of the stakeholder interviews: that energy security improvement was the most favourably evaluated was consistent with the interviews where only a positive impact was predicted for energy security; implemental impact was predicted to be the most negative aspect for farm operators, which was consistent with the interviews where even farm operators who installed AVSs commented on the negative aspect of implementation; energy security was an important factor for more positive global and future generational levels of impact for all the sectors except for farm operators, which was consistent with the interviews where only farm operators failed to indicate energy security impact.

The survey clarified three additional important findings that were not identified in the interviews: farm operators generally predicted rather more positive local impacts than the impacts for themselves when they installed AVSs, global and future

Table 5
Quantitative survey sample.

Specification	Number of samples
Farm operators	153
Workers in the agricultural sector	153
Local residents	208[a]
Total sample size	514
Response rate (%)	65.8

[a] Of 208 samples, 104 live near farming plots while 104 live far from those.

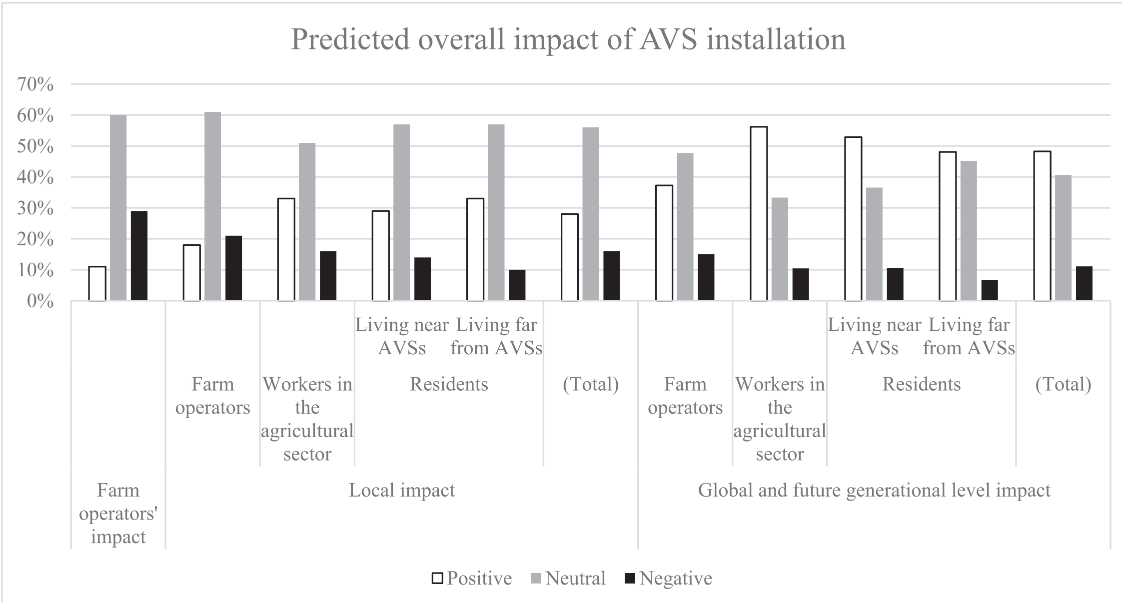

Fig. 3. Results of the survey.

generational levels of impact tended to be predicted as more positive than that at the local community level, and residents living far from farmlands and therefore, far from installed AVSs predicted a positive energy security impact.

In terms of farm operators' perceived individual and local impact, more than 40% of respondents indicated either a positive or negative impact. In terms of impact at global and future generational levels, 60% perceived some kind of potential impact. Over 50% did not offer a view on positive or negative effects at an individual or local level, and 40% had no view to express at global and

Table 6
Results of the survey.

Farm operators' perceived individual impact

Impact	Evaluator: Farm operators Positive (%)	Evaluator: Farm operators Negative (%)
Overall	11.2	29.4
Economic	19.0	27.5
Implemental	13.1	28.7
Environmental	20.3	26.1

Local community level impact

Impact	Evaluator							
	Farm operators		Workers in the agricultural sector		Residents Living near farmlands Living far from farmlands			
	Positive (%)	Negative (%)	Positive (%)	Negative (%)	Positive (%)	Negative (%)	Positive (%)	Negative (%)
Overall	18.3	20.9	33.4	16.3	28.8	14.4	32.6	9.7
Economic	22.3	17.0	52.3	13.1	37.5	10.6	47.1	6.8
Implemental	15.0	21.0	33.3	27.5	28.8	18.3	33.6	8.6
Energy security	37.9	9.8	58.2	6.6	51.0	10.6	48.1	2.9
Environmental	26.8	20.2	44.5	19.0	39.4	17.3	33.6	14.5

Global and future generational level impact

Impact	Evaluator							
	Farm operators		Workers in the agricultural sector		Residents Living near farmlands Living far from farmlands			
	Positive (%)	Negative (%)	Positive (%)	Negative (%)	Positive (%)	Negative (%)	Positive (%)	Negative (%)
Overall	37.2	15.0	56.3	10.4	52.9	10.6	48.1	6.8
Economic	32.7	13.8	49.7	11.1	56.7	11.6	54.8	5.8
Implemental	24.2	19.0	32.1	19.6	36.5	20.2	35.5	9.7
Energy security	43.1	7.2	56.2	8.5	60.6	5.8	55.7	3.9
Environmental	30.7	11.8	47.0	10.6	49.1	19.3	40.4	10.6

future generational levels.

The factors that were potentially related to evaluations of AVSs were analysed through regression analyses by setting perceived overall impact as the explained variable and potential determinants as explanatory variables. Only significant factors (more significant than a 10% level) were considered in the results. Neither of the following two categories of factors were related to farm operators' overall evaluation of AVSs: 1) farm management-related factors, such as working in agriculture full-time, having agricultural successors, areas of cultivated land, using farmland that is promoted by the government for agriculture, or having abandoned farmland; or 2) farm operators' environmental statuses, including their environmental impacts, their positive local energy security impacts, or their levels of trust in PV or AVS companies. The following factors were not related to all stakeholders' evaluations of impact: gender, age, education, marriage, and living in an agricultural area or in particular areas in Japan including Tohoku, Kanto-Koshin and Shikoku.

(a) Farm operators' perceived individual impact (Table 7)

Question 1: How many farm operators may be interested in installing AVS?

Among the farm operators (153 persons), 17 persons (11%) perceived an overall positive potential impact and 45 persons (29%) perceived a negative impact. The rest (60%) were indifferent. Therefore, it was suggested that 11% of farm operators may be interested in installing AVS. In particular, farm operators who had not introduced PVs, but predicted a positive impact from AVSs, accounted for as much as 8.5%, indicating they could be more interested in installing AVSs in the near future.

Question 2: What characteristics/factors are related to the prediction of an overall positive impact?

The largest factors in farm operators perceiving a more positive impact than other farm operators and thus, signalling they could possibly become potential installers, were more positive predictions of the economic impact and implementation flexibility impact of AVS installation, and more experience installing RETs at home. Other slightly relevant factors to perceive a more positive overall impact were that less concern over food safety and the future of Japanese food security, more desire to use PV electricity themselves or locally, more relatives or acquaintances, who had installed an AVS or a PV, and more involvement in working for a fee.

None of the farm operators who perceived an overall positive potential impact perceived any negative economic impact from AVSs, suggesting that a positive perception of economic impact was linked to an overall positive evaluation of AVSs. A total of 94% of farm operators who perceived an overall positive potential impact did not indicate any negative impact concerning flexibility of implementation and the environment, suggesting that a lack of perceived negative impact in terms of these two features also had a major influence on the overall positive evaluation of AVSs.

Question 3: Are there any specific, negative impacts predicted by the farmers predicting an overall positive impact?

Even among farm operators who predicted an overall positive impact (17 persons), one operator predicted a negative impact on flexibility, and another operator predicted a negative impact on the environment. Other operators did not predict any specific negative impact.

Question 4: How could positive impact be enhanced and negative impact be mitigated?

Specific impacts, including likely economic impact, implementation flexibility impact and environmental impact arising from AVS, and farm operators' mindsets regarding trust in AVS promoters could possibly be changed so that farm operators might predict better impacts of AVS installation. As there was little information available to farm operators regarding specific types of impacts for reference, predicted impact might have changed if farm operators had information regarding examples of favourable economic outcomes of the installation of specific types of AVS, good agricultural practices, or the management of specific types of AVS systems. In addition, it was suggested that only specific types of AVSs, which generate positive economic and non-negative environmental and implemental impacts, should be considered to have a more positive impact. In terms of possible changes in mindset, it was predicted that farm operators' mindsets might change if awareness building activities were developed so that AVS promoters could become more trustworthy to farm operators.

(b) Local community level impact (Table 8)

Question 1: How many stakeholders in the local community predict an overall more positive or than and negative impacts from the installation of AVSs? Is AVS generally acceptable to by local people?

Table 8 shows that all the stakeholders, except the farm operators' group, perceived a more positive impact, while the farm operators' group perceived a more negative (32 persons, 21%) than positive (28 persons, 18%) potential impact, although it was not statistically significant. Among those employed in the agricultural sector, 33% predicted a positive impact, and 16% predicted a negative impact. Residents living far from AVSs perceived a more positive potential impact (33%) and fewer a negative impact (10%) than

Table 7
Analyses regarding the four questions on the individual-level potential impact.

Question 1: How many farm operators may be interested in installing AVS?
8.5%–11% of farm operators
Question 2: What characteristics/factors are related to the prediction of overall positive impacts?
More positive predicted economic impacts and implementation flexibility impacts of AVS installation (***)
More experience of installing a RET at home (**)
Less concerned for food safety and Japanese future food security (*)
More desire to use PV electricity by themselves or locally (*)
Had more relatives or acquaintances who installed an AVS or a PV (*)
More involved in paid work (*)
Question 3: Are there also specific negative impacts predicted by farmers predicting overall positive impacts?
Predicted negative impact on flexibility and the environment (by one operator, respectively)
Question 4: How could positive impacts be enhanced and negative impacts be mitigated?
Provide information to farm operators regarding examples of favourable economic outcomes of the installation of specific types of AVSs
Provide information to farm operators regarding examples of good agricultural practices or management for specific types of AVS systems
Only specific types of AVSs that were identified as generating positive economic and non-negative environmental and implemental impacts should be introduced
Conduct awareness building activities for AVS promoters

(*), (**), and (***) indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 8
Analyses regarding the four questions on the local community-level potential impact.

Question 1: How many stakeholders in the local community predict more positive than negative impacts from the installation of AVSs? Is AVS generally accepted by local people?
Overall impact
Farm operators: 18% was positive, 21% was negative.
Workers in the agricultural sector: 33% was positive, 16% was negative.
Residents (near AVSs): 29% was positive, 14% was negative.
Residents (far from AVSs): 33% was positive, 10% was negative.
Acceptance
AVSs are likely to be accepted locally except among farm operators while energy security is the most positive impact.
Question 2: What characteristics/factors are related to different stakeholders' positive evaluations regarding overall impacts?
Farm operators
Predicting more positive local environmental impact (***)
Predicting more overall positive impact to themselves (***)
Having less relatives or acquaintances who installed an AVS or a PV (***)
Think more that AVSs are supported by the government (**)
Having lower household incomes (**)
Predicting more positive local economic impact (*)
Trust more in administrative agricultural policy and energy policy (*)
Shorter distance from the nearest farmlands from house (*)
Workers in the agricultural sector
Predicting more positive local economic impact (***)
Predicting more positive local environmental impact (***)
Predicting more positive local flexibility impact (**)
Not living in the Kyusyu area (**)
Less number of household members (*)
Residents (near AVSs)
Predicting more local flexibility impact (***)
Predicating more positive local environmental impact (**)
Having experience of installing a PV (**)
No experience of installing a solar thermal system at home (**)
Having more knowledge of RET or environmental problems (*)
Not living in the Chugoku area (*)
Residents (far from AVSs)
Predicting more positive local environmental impact (***)
Predicting more local flexibility impact (**)
Trust more in administrative agricultural policy and energy policy (**)
Thinking more that AVSs are supported by the government (*)
Question 3: How could positive impacts be enhanced and negative impacts be mitigated?
Only specific types of AVSs identified to generate non-negative environmental and implemental impacts are disseminated locally.
The government supports AVSs more explicitly if they regard AVSs having positive impacts.
Investigate the reasons for the negative evaluation of residents in the Chugoku and the Kyusyu area

(*), (**), and (***) indicate significance at the 10%, 5%, and 1% levels, respectively.

residents living near AVSs, 29%, and 14% of whom perceived a positive and a negative potential impact, respectively, although these differences were not statistically significant. The positive local impact, perceived as particularly significant, involved energy security. Overall, the results indicate that AVSs are likely to be accepted locally, with the exception of farm operators, while energy security is the most positive impact.

Question 2: What characteristics/factors are related to different stakeholders' positive evaluations of overall impact?

Although there were slightly different kinds of impact perceived by different stakeholders, predicting more positive environmental and implemental impacts was among the most important factors explaining the prediction of an overall positive local impact. This seems to be because energy security impact was acknowledged widely while environmental and implemental impacts were more often regarded as negative. Therefore, they seemed to predict an overall more positive impact, locally, when they predicted relatively more positive environmental and implemental impacts than other respondents. Predicting more positive local and personal economic impacts, trusting more in administrative agricultural policy, believing more strongly that the government supports AVS, and living in places other than specific areas were also important factors for positive evaluations. Factors of positive evaluations for each stakeholder are summarised in Table 8.

Question 3: How could positive impact be enhanced and negative impact be mitigated?

It was suggested that only specific types of AVS, which were identified as generating non-negative environmental and implemental impacts, should be disseminated locally to generate more predictions of a positive local impact. It was also suggested that the government needs to support AVS more explicitly if it regards AVS as having a positive impact. Further investigations regarding the reasons for the negative evaluation of residents in specific areas would lead to understanding how negative impact could be mitigated.

(c) Global and future generational levels of impact (Table 9)

Question 1: How many stakeholders in the local community predict an overall more positive or than and negative impacts from the installation of AVSs? Is AVS generally acceptable to by local people?

Contrary to local-level impact, farm operators, who perceived an overall positive potential impact (37%), significantly outnumbered those who perceived a negative impact (15%). Other sectors also predicted general/future impact would be much more positive than the local impact (Table 6).

AVSs are likely to be accepted locally while energy security and economic impacts are mostly predicted to be positive. Energy security received the most mentions as a positive impact, by 43% of farm operators, 56% of those employed in the agricultural sector, 61% of residents living near AVSs, and 56% of residents living at a distance from AVSs, respectively. At least half of the stakeholders

Table 9
Analyses regarding the four questions on global and future generational level impact.

Question 1: How many stakeholders in the local community predict more positive than negative impacts from the installation of AVSs? Is AVS generally accepted by local people?
Overall impact
Farm operators; 37% was positive, 15% was negative
Workers in the agricultural sector: 56% was positive, 10% was negative
Residents (near AVSs): 53% was positive, 11% was negative
Residents (far from AVSs): 48% was positive, 7% was negative
Acceptance
AVSs are likely to be accepted locally while energy security and economic impacts are most predicted to be positive.
Question 2: What characteristics/factors are related to different stakeholders' positive evaluations regarding overall impacts?
Farm operators
More positive global/future environmental impact (***)
Having experience in installing a PV in work (***)
NOT more than three PV systems have been installed near the respondent's house (***)
More positive global/future economic impact (**)
Think more that this questionnaire is meaningful (**)
An AVS has NOT been installed near the respondent's house (**)
Living in Hokuriku area (**)
Less interested in environmental problems (*)
A PV system has NOT been installed near the respondent's house (*)
Workers in the agricultural sector
More positive global/future environmental impact (***)
More positive global/future energy security impact (***)
Less interested in environmental problems (**)
DOESN'T think that AVSs are supported by the government (**)
NOT more than three PV systems have been installed near the respondent's house (**)
Regard environmental education as important (*)
A PV system has been installed near the respondent's house (*)
Residents (near AVSs)
More positive global/future flexibility impact (***)
More positive global/future energy security impact (***)
NOT living in the Chugoku area (***)
Want to use PV electricity by myself or locally (*)
Residents (far from AVSs)
NOT more than three PV systems have been installed near the respondent's house (***)
More positive global/future economic impact (***)
More positive global/future energy security impact (***)
Have experience of installing a solar thermal system in my work (***)
Two PV systems have been installed near the respondent's house (***)
Have less knowledge of AVS technologies, policies and subsidies (**)
Have more knowledge of RET or environmental problems (**)
Have NO relatives or acquaintances who installed an AVS or a PV (**)
NOT living in the Chugoku area (**)
Want to use PV electricity by myself or locally (*)
Have experience of installing a PV at home (*)
NOT living in the Tokai area nor the Kinki area (*)
Question 3: How could positive impacts be enhanced and negative impacts be mitigated?
Find ways for AVSs to accommodate rural landscape and the environment
Undertake devices to improve energy security by the usage of local installation of AVSs
Investigated the reasons for the negative evaluation of residents in the Chugoku area

(*), (**), and (***) indicate significance at the 10%, 5%, and 1% levels, respectively.

perceived a positive potential economic impact, comprising 50% of those employed in the agricultural sector, 57% of residents living near AVSs, and 55% of residents living far from AVSs.

Question 2: What characteristics/factors are related to different stakeholders' positive evaluations regarding overall impact?

More positive global and future generational levels of environmental impact were the largest factors for farm operators and those employed in the agricultural sector for evaluating AVS as having a more overall positive impact at the global and future generational levels. Having a more positive global and future generational level of energy security was a significant factor to all those except for farm operators when predicting an overall positive global/future impact. It was suggested that having personal experience in installing PVs tended to correlate with a positive overall impact at the global and future generational levels from AVSs, while an oversaturated concentration of PVs near one's house was a factor for predicting AVSs to have negative impacts at global and future generational levels. Farm operators and those employed in the agricultural sector who were more interested in environmental problems tended to predict more negative global and future generational level impacts from AVS. Living in particular places, especially in the Chugoku area, led to predictions of a more negative global/future impact from AVS.

Question 3: How could positive impacts be enhanced and negative impacts be mitigated?

If there were known ways for AVS to accommodate rural environments, then a more positive impact could be predicted. The predicted positive global and future generational energy security impacts would be more enhanced if devices were developed to improve energy security through the local installation of AVS. Further investigations regarding the reasons for the negative evaluations of residents from a particular area would lead to more in-depth understanding of how negative impacts could be mitigated.

(d) Quantitative survey conclusions

Although many farm operators predicted a negative personal impact overall from installing AVS, AVSs were generally accepted locally and were well accepted when global and future generational level impacts were considered. Considering that only farm operators who predict positive impact for themselves would introduce AVSs, it seems that AVSs were predicted to produce positive impacts for many local stakeholders. To further enhance the positive impact of AVS installation, it would be better to develop particular devices to improve energy security from the local installation of AVSs.

On the other hand, to mitigate any perceived negative impact from AVS installation, the following would be necessary: provide information to farm operators regarding specific examples of favourable economic outcomes, good agricultural practices and the management of the installation of specific types of AVSs; only disseminate specific types of AVSs identified as generating positive economic and non-negative environmental and implemental impacts; develop more awareness-building activities; encourage better government support of AVS if the government regards AVS as having positive impacts; and investigate the reasons behind the negative evaluation of residents in particular areas.

3.3. SSIS could facilitate collaboration for developing sector-wide strategies

The case indicates that SSIS could lead to the completion of the full phase of SIA afterward. SSIS reminded Kyokai of the need for sector-wide collaboration to develop further activities with the authors that would enhance positive social impact and mitigate negative social impact due to AVSs. At the time of writing, Kyokai was considering implementing the remaining phases to have a full SIA in addition to SSIS by developing a collaborative Social Impact Management Plan (SIMP) that would detail actions at association and promoter levels.

The SIMP took into account a number of issues. First, the SSIS identified the need for the provision of relevant concrete information to support potential AVS installers in understanding the best practices of particular types of AVSs. This information would include economic simulations of an AVS for each crop, potential additional work burdens if AVSs were introduced and how these could be managed, examples of methodologies to create benefits for agricultural work through the introduction of AVSs, examples of methodologies to create environmental benefits, and standardised contracts that may reduce risks compared to the status quo. Such informational provision is predicted to lead to the dissemination of only specific types of AVSs identified as generating positive economic and non-negative environmental and implemental impacts.

The SSIS also identified a need for further perception surveys and expert analysis to identify potential environmental impacts associated with particular types of AVS installations and ways to mitigate any negative effects. For example, it was predicted that an environmental impact perceived by residents living nearby would be quite different, depending on where the AVSs were located, what crops were cultivated, and how solar panels were set on farmlands. Therefore, further detailed assessment and strategies were found necessary for groups of different types of AVS applications within the sector. The need for further survey work was also identified in order to inform the design of an appropriate mechanism so that issues could be addressed by AVS promoters, who could then win the trust of farm operators more generally. This assessment phase would also include an expert examination of the systems that would enhance local energy security through using AVSs, analyses of their costs, and the most effective means of informing farm operators and local residents. After Kyokai considered the findings of the SSIS and the preparation of a SIMP, one Kyokai member company started to sell an AVS system designed to enhance the local community's energy security. The system was designed to equip local disaster prevention by providing night-time lighting and electric outlet for the community during blackouts caused by unexpected incidents such as mass disasters.

Implementation progress would be supported by periodical monitoring of the status of each action in the SIMP. The strategies to be used and the SIMP were to be revised as necessary within three to five years.

4. Discussion

This study applied the SSIS method to AVSs in Japan, which, to the authors' best knowledge, is the first study of its type conducted by a Japanese private sector group. Full-phase international standard SIAs have not been conducted in Japan as far as the authors are aware [11], and even the first phase (issues scoping) has rarely been undertaken. Therefore, the implementation of this SSIS was a landmark event, which is likely to be valuable in promoting SIA practices in Japan, maximising social value brought about by RET development projects.

Full-phase international standard SIAs have not been conducted in Japan partly because of their challenging nature due to the Japanese social context. Few citizens seem to have experience in public discussions and, therefore, many stakeholders are unlikely to be accustomed to articulating their objections to particular interventions in public, even when opposed [12]. This suggests that group discussions may not be the best method in many cases involving the public evaluation of interventions in Japan. On the other hand, research has indicated that survey methods may promote opportunities for otherwise reticent stakeholders to express their opinions [7,25].

The fact that over 50% did not offer a view on positive or negative effects at the farm operators' level, and 40% had no view on global and future generational levels, indicates that many Japanese stakeholders may be indifferent to AVS dissemination. It might be contended that this evidence suggests approximately half of Japanese people felt that these types of policy issues were beyond their concern. However, this finding does not indicate that SSIS would be unnecessary for Japanese project evaluations, as a substantial number of other stakeholders had real concerns. Evidence in support of SSIS was suggested in the responses concerning whether the questions posed were meaningful. Although 46% of the respondents were neutral, implying that a considerable percentage of stakeholders were not interested in the SSIS approach or in AVS issues, the remaining 54% did express concern. This is an interesting finding because Japanese stakeholders usually are apparently uninterested in public policy/project decision making and tend not to express their opinions on public policies/projects in public. Japanese people may be rather unaccustomed or hesitant to express their opinions publicly concerning social policies/projects. While 13% of respondents did not believe the research was meaningful, 41% did think it meaningful, suggesting that many stakeholders felt that SSIS would be able to achieve its aim of usefully exploring the social impact of RET.

SSIS enabled various stakeholders to put forward their views. SSIS was able to determine how various social impacts of RET were perceived by each group of otherwise reticent stakeholders, and identified the need for further activities. SSIS can be especially effective in scoping interventions where there is no substantial budget involved. SSIS would create better outcomes in many cases where there are otherwise no plans for analysing the social impact of interventions concerned.

SSIS could also lead to the full phase of SIAs involving the management of interventions and improving the cumulative social impact generated by each small-scale AVS. The best practices undertaken by AVSs could be communicated to other AVS associations so they could learn them. Moreover, it is unrealistic to hope that policy makers may eventually learn from these best practices, which would generate even larger social benefits. SSIS can be effective not only in Japan but also in other Asian regions where public consultations and discussions may be less successful.

5. Conclusion

This study proposed the SSIS method, a scoping of sector-wide general social impact of RETs, as a methodology for examining the social desirability of RETs by analysing their perceived potential social impact through a mixture of simple social research methods including literature review, exploratory interviews, stakeholder interviews, and surveys. This study applied SSIS on AVSs in Japan, which, to the authors' best knowledge, is the first study of its type conducted by a Japanese private sector group.

The AVSs seemed to be able to produce positive impacts on many local stakeholders. Employing particular AVS systems to further improve energy security would be effective in enhancing the positive impact of an AVS installation. On the other hand, to mitigate any perceived negative impact of an AVS installation, the following were recommended: the provision of information to farm operators with specific examples of favourable economic outcomes, good agricultural practices, and the management of the installation of specific types of AVSs; the identification of specific types of AVSs that would generate positive economic and non-negative environmental and implemental impacts; and the conducting of awareness-building activities for AVS promoters.

SSIS allows the views of reticent stakeholders to become known and provides the tools for effective preliminary scoping of RETs. SSIS cautioned project proponents of potentially undesirable social impacts that RET may generate, which have often been neglected. SSIS could eventually lead to full-phase of SIAs involving the management of the identified cumulative social impact generated by each small-scale AVS. Policy makers should undertake SSIS for RET to reveal the variety of views among otherwise reticent stakeholders, so that they can eventually increase the positive impact and mitigate negative impacts of the RET. The SSIS approach can be effective not only in Japan but also in other Asian regions, where public consultations and discussions using the full standard SIA may be less successful.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.renene.2019.02.048.

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