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Managing Conflicts with Local Communities over the Introduction of Renewable Energy: The Solar-Rush Experience in Japan

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Received: 6 July 2020; Accepted: 19 August 2020; Published: 23 August 2020



Abstract: A worldwide introduction of renewable energy has been required to reduce greenhouse gas emissions. Concomitantly, this has caused conflict between renewable energy development and local communities over landscape changes. This study aims to clarify the factors of conflict and find a way of conflict management. A case study on Japan is used, where a solar rush occurred due to the feed-in tariff (FIT) system. We analyze the public reasons to worry about renewable energy and the spatial characteristics of its locations. A socio-spatial approach is used by first utilizing a qualitative survey based on questionnaires and interviews with the local governments to understand the awareness regarding the issues, and then utilizing a quantitative survey on the location changes to solar power by using GIS. The results suggest that there were links between local governments' concerns and the location of solar power concentration. These results show that conflicts over renewable energy are not unavoidable and may be managed by local governments that can act as intermediaries with sufficient knowledge of the local communities.

Keywords: renewable energy; solar rush; local community; landscape; peri-urban agricultural area; conflict management

1. Introduction

Renewable energy is the key to reducing greenhouse gas emissions due to the use of fossil fuels. In further promoting the adoption of renewable energy, two types of barriers must be overcome. One is technical and the other is social. The development of technology, such as equipment that enhances the efficiency of energy production and research in intelligent design, is progressing rapidly. The latest research also proposes renewable energy as a green infrastructure [1]. However, it takes a considerable amount of time to determine how to solve social issues such as negative impressions and the opposition to and rejection of renewable energy by local communities. Due to the difficulty in solving conflicts between those developing renewable energy and the local communities, many renewable energy facilities are still operating in the face of conflict. Frolova et al. [2] point out that in European countries, various renewable energy technologies have affected land use and the landscape, based on a review of

empirical research on renewable energy from thirty-seven countries. Among them, wind and solar power plants added strongly contrasting artificial elements to the landscape. Additionally, the recent surge in the proportion of solar power generation compared with the world's total renewable energy is remarkable [3]. Therefore, it is highly necessary to consider the impact of solar power on local communities. As a premise to promote the introduction of further renewable energy in the future, effective measures to solve conflicts must be designed.

In Japan, a nuclear accident occurred due to the tsunami following the 2011 Great East Japan Earthquake, which generated an acute energy shortage. In response to this energy crisis, the central government introduced the feed-in tariff (FIT) system to promote the introduction of renewable energy. The FIT system is a fixed purchase price system for renewable energy. There were two main reasons for introducing the FIT system in Japan. As will be explained in detail later, one reason was that the percentage of power generated by the nuclear power plant immediately before the accident had reached 21.7% of the total consumed power. However, owing to the accident, the nuclear power plants across the country lost the trust of the people and were forced to stop operations. In order to cover the demand, it was necessary to urgently increase the supply of clean power. The other reason for introducing the FIT system was that Japan has not made much progress in the utilization of renewable energy, so it was necessary for the central government to effectively promote such use.

In Japan, the FIT system caused a phenomenon called “solar rush”, in which solar power increased rapidly nationwide. In Japan's FIT system, the central government guarantees that electric power companies will purchase electricity generated from renewable energy at a fixed price for a fixed period. The funds for the purchase are collected automatically from all electric users as “renewable energy installment money”. Therefore, the government and the suppliers were able to adopt this system without hesitation. A solid income is guaranteed, even if the supplier only has the land to install the plant and the initial financial investment for purchasing the equipment. Various suppliers, from individuals to companies, competed to enter the solar power business, which was easy to introduce. Consequently, conflicts occurred between the communities and solar power providers in various parts of Japan. Conflicts between local communities and renewable energy facilities were concentrated within a shorter period of time in Japan than in other countries. Furthermore, because the solar rush was observed across the entire country, it is possible to clarify under what conditions the conflict between solar power and the local communities will occur.

Nevertheless, in exchange for the success of the FIT system, conflicts between suppliers and local communities developed into a social problem that the central government could not overlook. Japanese local governments have experience in implementing community-based land-use management through ordinances. However, despite the significant changes in local land use brought about by the introduction of renewable energy, the cooperation between local communities and renewable energy was not fully considered, and inevitably, conflicts had become more serious. This study thus investigated these issues from a spatial-social perspective by focusing on the “solar rush” phenomenon in Japan. We hypothesize that the conditions under which conflicts occur between communities and renewable energy development have spatial characteristics. Therefore, this study aims to identify issues through an analysis of the spatial characteristics of the places where the local community has concerns, and renewable energy projects are concentrated. A coordinating body to manage conflicts is also necessary. For local conflicts, the local government would be suitable as a conflict coordinator. Local governments have played a major role in resolving previous conflicts between local communities and developers.

Despite the rapid increase in renewable energy studies and that some studies have claimed the importance of collaboration with communities, the spatial-social approach has not been undertaken fully. It is unclear where and what kinds of issues will occur when trying to introduce renewable energy. Concomitantly, many studies addressing conflicts with the local community related to renewable energy specify the target area in advance. For this reason, spatial differences in the impact of the introduction of renewable energies have not been sufficiently clarified. Our main research contribution

is identifying the factors of conflict by pinpointing the public issues related to the location of solar power, analyzing the locations where solar power locations are concentrated, and finding a way of conflict management regarding the introduction of renewable energies. We employ a socio-spatial analysis approach for a comprehensive consideration of the social factors and spatial characteristics.

This study is organized as follows. Section 2 reviews the literature on conflicts about renewable energies and local communities. In Section 3, we briefly describe the energy characteristics of Japan, the subject of our case study. In Section 4, we outline the methodology of this study. Section 5 shows the results of our analysis. In Section 6, we discuss our results. Finally, Section 7 presents the conclusions of our study, and highlights its findings and contributions.

2. Literature Review

This study aims to identify the factors of conflict and find a way of conflict management based on the analysis of both the public reasons to worry about renewable energy and the spatial characteristics of its locations through a case study on solar power in Japan. We first review the literature on the public perception of renewable energy. We also review the factors related to the cause of conflicts. Secondly, the literature on conflict management methods are reviewed. Thirdly, we review studies based on the socio-spatial approach. Based on the work of Frolova et al. [2], we reviewed the literature focusing on solar and wind power that are particularly characterized by conflicts with local communities.

As for the first item, researchers have explored measures to reveal public opinions about renewable energy. Nascimento et al. [4] clarified that the issues creating barriers to the introduction of solar power are diverse, such as panel quality, installation costs, lack of technical knowledge, and inefficient after-sale service [5]. Similar issues have been presented for solar water heating systems [6]. Nikas et al. [7] argued that citizen involvement is important for sound, acceptable, and effective policymaking in the process of introducing alternative energy. Jong et al. [8] analyzed the historical energy-landscape over time in the Netherlands and showed the trend of change is becoming more dynamic. A survey of residents in the area where an offshore wind farm is planned off Cape Cod found that the majority of the population was concerned about the impact on the natural environment and a much smaller portion of the population expected a positive effect [9]. A questionnaire survey of local residents conducted in Italy revealed that there are various preferences for wind, solar, biomass, and nuclear energy [10]. Even though the type of renewable energy to be preferred depends on the characteristics of the inhabitants, it was found that there are always inhabitants who cannot accept whatever type of renewable energy is selected [11]. Residents' perceptions of renewable energy in Portugal were diverse [11]. This research also showed that it is necessary to continuously investigate changes in awareness not only at the planning stage but also at the operational stage [11]. However, issues similar to conflicts between the renewable energy locations and local communities arose in the late 1980s in city planning [12]. Even if the facility is indispensable to the local community, it cannot be installed anywhere because the neighboring residents do not want to build it next to their home. This phenomenon was named not-in-my-backyard (NIMBY). This situation can especially occur when governments, private companies, NPOs, and others try to build facilities, such as prisons, highways, and homeless shelters. Dear [12] defined NIMBY as the protectionist attitudes of and oppositional tactics adopted by community groups facing an unwelcome development in their neighborhood. For this reason, some studies have analyzed the perception of renewable energy facilities as a NIMBY phenomenon. Bell et al. [13] demonstrated that residents tended to accept renewable energy when it did not affect themselves but did not want it in their neighborhood; that is, NIMBY. Horst [14] argued that responses to renewable energy vary from one individual to another. He indicated that some residents are afraid that they will be labeled NIMBY because they oppose renewable energy. In light of these suggestions, acceptance of renewable energy in a local community require achieving a balance between controlling the personal and public interests of individuals from a local perspective.

The factors related to the cause of conflicts are pointed out based on previous studies. Wustenhagen et al. [15] argued that paying attention to social acceptance is important in the introduction

of renewable energy and that it was largely neglected in the 1980s when such policy programs began. This neglect continued in the 1990s due to a high level of public support for renewable energy technologies. They also pointed out that transforming local initiatives into more supportive policies would impact social acceptance [15]. D'Souza et al. [16] and Simcock [17] argued that “procedural justice” to avoid conflicts should also be considered for private wind farms installed by the rural local community. Regarding solar power, Prados [18] found that, in rural areas of Andalusia, a chaotic sprawl of solar power is going on, and the application of solar power needs to be adapted to local spatial and landscape plans to solve this conflict. Among renewable energy technologies, solar and wind power are often the targets of conflict within the rural local communities. Measures for social acceptance by the residents regarding renewable energy have been described, especially in the field of wind power. D'Souza et al. [16] suggested that the factor that most strongly correlated with wind power social acceptance is “concerns with wind turbines”. Pasqualetti [19] studied the nature of the challenges for renewable energy projects for geothermal, wind, and solar energy in the United States, Scotland, and Mexico. They found that a common threat perceived by the public was landscape change. From these previous studies, conflicts in the acceptance of renewable energy in the local community can be defined as follows: The lack of efforts for social acceptance in local communities through policies of local governments is an issue. To this end, it is necessary to transform community initiatives into supportive policies. For instance, aligning the location of renewable energy with regional spatial and landscape plans is desirable. The other is the lack of effort to reduce concerns about renewable energy in the local community. Typical concerns of renewable energy in the community are safety and landscape destruction. However, the location of the characteristics where such local community concerns will occur has not been clarified in the literature.

Next, we examine the literature on the issue of conflict management regarding renewable energy. Many studies have described ways to reduce the frictions with the local community regarding renewable energy. For example, one hypothesis proposes that smaller utility-scale solar energy projects would be effective in reducing the impact of solar power on the local landscape [20]. It has been found that the proposed tool for assessing the aesthetic impact of a solar power project on the local community is to select the optimal plant location and the most appropriate use of panel technology [21]. Proposals have also been made for the design of solar panel installation methods [22]. In Spain, a method has been proposed to assess the impact of renewable energy on the local landscape [23]. In the Slovenian awareness survey on solar power, the impact of the panels on the local community was noted as a major concern [24]. These are mainly studies on reducing the impact on the local community from a technical viewpoint. The results of the proposals in renewable energy have been mainly limited to computerized landscape simulations. In reality, many renewable energy projects are causing conflicts with local communities due to landscape changes. For this reason, it is essential to analyze the characteristics of the location of renewable energy projects. Nevertheless, few studies have analyzed the relationship between social acceptance of renewable energy and spatial characteristics.

Thirdly, we review studies that use socio-spatial approaches. The socio-spatial approach is effective as a method for comprehensively analyzing social issues, such as conflicts, by associating them with space. Through socio-spatial analysis, Moreno-Jiménez et al. [25] revealed that vulnerable population groups, such as immigrants and the elderly, are exposed to severe air pollution. Magnani et al. [26] studied the relationship between tax exemption and building renovation. Liu et al. [27] adopted the socio-spatial approach and analyzed the relationship between the location of complaints and the spatial characteristics in the municipality. They revealed that complaints tend to be concentrated in certain places. Our study also refers to this approach and undertakes an analysis based on the assumption that there are places where the issue is concentrated.

Renewable energy and community conflicts are a common global issue, and sharing knowledge with international readers is one of the reasons for conducting this research. Research on Japan's renewable energy problems is often an analysis of places where specific cases of conflict have occurred [28,29] and areas where there is concern about the occurrence of conflict [30]. A feature of

these studies is that they frequently mention the need for cooperation between local governments and communities. This is because Japan's pioneering local governments have experience in adopting community-based land-use plans in the 1990s to prevent the destruction of the natural environment due to the resort development boom [31]. In this respect, land-use control by local governments has the potential to be one of the means to resolve conflicts between renewable energy development and local communities. Conversely, most of the internationally pioneering work on conflicts between local communities and renewable energy development has been based primarily on social policy approaches. These studies have not paid sufficient attention to the spatial characteristics in which conflicts occur. This is because much research is on conflicts where problems have occurred or on specific case studies. However, in Japan, a nuclear power plant accident caused a nationwide solar rush. For this reason, the conflicts are more intensive than in other countries, and the spread of solar power throughout the country makes it possible to clarify the geographic characteristics of areas where conflicts are likely to occur or are concentrated. Therefore, it is possible to analyze the situation from a socio-spatial approach, which has been rarely done so far. The socio-spatial approach manages social conflicts that were difficult to deal with by conventional technical approaches and is expected to enhance the effectiveness of the technical approaches that take into consideration reasons for conflict that are appropriate to specific features of the landscape and not necessarily due to emotional reactions. Furthermore, by analyzing the location characteristics from the spatial aspect, there is a possibility that it will open the way to the solution of the NIMBY problem, which was the disadvantage of the socio-political approach [14,16,32]. It can also offer effective methods for conflict management to local governments that are generally the mediators of conflicts in local communities.

This study aims to provide a new perspective on the issues of introducing renewable energy by adopting the socio-spatial approach. In previous studies, the issue of renewable energy was often examined in two simple categories: urban and rural [33]. For this reason, the effects on the suburbs have been overlooked. This is because the impact of landscape changes due to the insertion of renewable energy facilities in rural areas is stronger [34]. In the suburbs of Japan, solar panels are often installed on farmland where cultivation has been abandoned. Because solar companies seek land as well as investors, local land owners may rent land to the companies, or they may install their own solar power. Focusing on the power transmission infrastructure that is essential for the location of renewable energy technology, there is no doubt that a location in the urban suburbs is advantageous for electricity suppliers. The impact on suburban areas can be clarified because Japan has experienced a solar rush and renewable energy spread across the country.

3. Trends in Energy in Japan

Fossil fuels have been the driving force behind Japan's economic development since 1960. As a result, Japan suffered the double affliction of lowering its rate of energy self-sufficiency and increases in emissions of greenhouse gases. To address these issues, the central government started to examine policies to introduce nuclear power around the 1980s. On the other hand, renewable energy, which is also an effective means of improving the rate of energy self-sufficiency, had not progressed until the 2000s (Figure 1). As of 2010, Japan's renewable energy supply comprised only 3.2% of its energy supply. At that time, the amount of renewable energy was 3.3% of the total energy worldwide and 5.8% in Europe and Eurasia; in Japan the rate was lower than the average for developed countries [35,36]. Because of this, the government revised the "Basic Energy Plan" and "New Growth Strategy" in 2010 and set the goal of increasing the renewable energy supply ratio to 10% by 2020, which was three times that of 2010. In addition, in order to achieve this goal, the government introduced a new powerful renewable energy subsidy system, the feed-in tariff (FIT) system in 2012 and abolished the old Renewables Portfolio Standard (RPS) system.

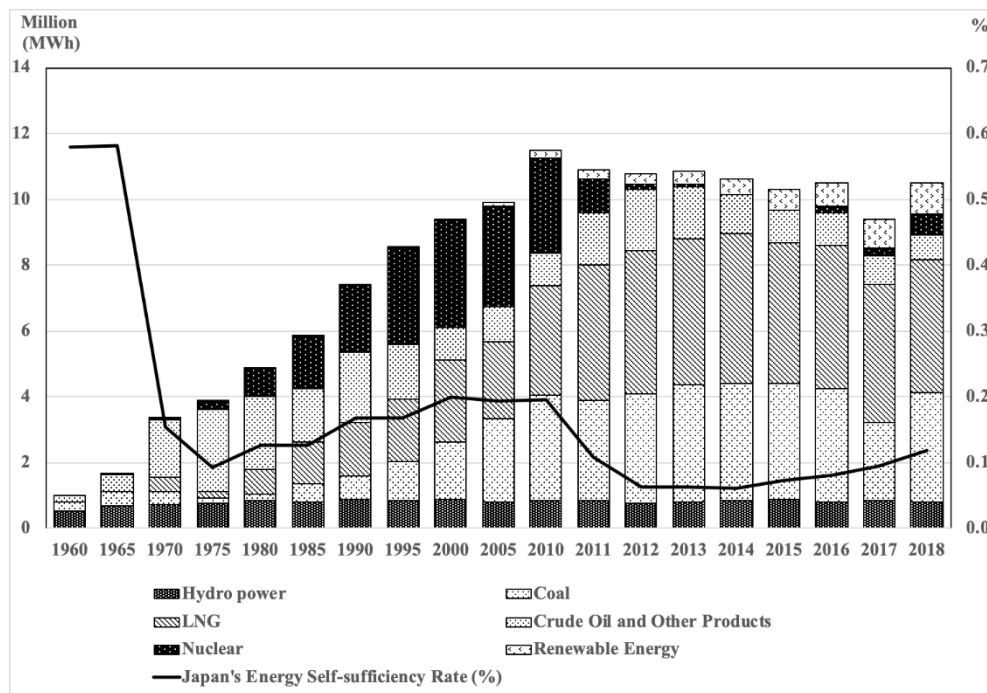


Figure 1. Transitions in the primary energy supply of Japan, 1970–2016 (source: Ministry of Economy, Trade and Industry, 2018 [37]).

When the FIT system was beginning to operate in 2012, the purchase price of renewable energy was set to be significantly higher than what was previously thought. This result is because after the nuclear power plant accident caused by the earthquake in 2011, the power supply was insufficient. Table 1 shows the purchase price of energy in 2012 when the FIT system was introduced and in 2018 after the purchase price was reviewed. The purchase price of solar energy was 40 yen per kWh in 2012, which is the highest price compared to other means of renewable energy. The reason that the purchase price was significantly revised in 2018 is that the rapid increase in renewable energy resulted in serious social conflicts in local communities and the government could not ignore those issues. Figure 2 shows the increasing trend in renewable energy capacity from 1990 to 2016 (Institute for Sustainable Energy Policies, 2017). Solar power was the largest beneficiary of the FIT system. This caused what we call the solar rush.

Table 1. Electricity purchase price by the feed-in tariff (FIT) system (source: Ministry of Economy, Trade and Industry).

Type	Minimum Purchase Unit (kW)	Purchase Period (year)	Purchase Price (yen/kWh)	
			2012	2018
Solar	10	20	40	28
Wind	20 or more	20	22	36
	offshore	20	20 + tax	36 + tax
Geothermal	15,000 or more	15	26	40
	15,000 or less	15	26 + tax	40 + tax
	1000–30,000	20	24	27–20
Hydropower	200–1000	20	29	29 + tax
	200 or less	20	34	34 + tax
	General timber	20	24	24
Biomass Power	Thinned wood 2000 or less	20	32	40
	Thinned wood 2000 or more	20	32	32

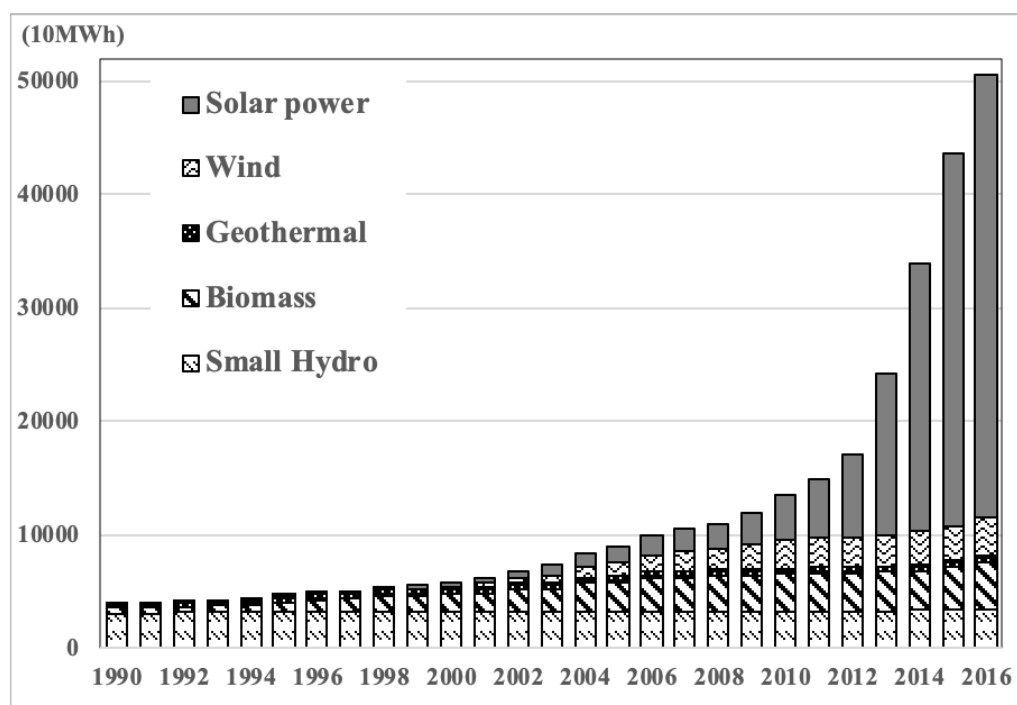


Figure 2. Trend in renewable energy cumulative capacity in Japan (source: ISEP, 2017 [38]).

In Japan, as pointed out by Tsujimura [39], only mega solar power projects are subjected to environmental assessment by law. These assessments mainly consider mitigation methods for the environmental impact and do not judge the suitability of the location of the solar power installations. In addition, there is no law that regulates consultation with local communities and local governments regarding the construction and installation of sites of small- and medium-sized solar power facilities [40]. In Japan, everyone knew that the rapid increase in renewable energy was triggered by the nuclear accident. Therefore, people were aware of the need for renewable energy. Still, social conflicts arose. In light of this situation, it is considered that the conflicts over solar power include not only the self-centered NIMBY approach, but also matters that could be managed from a neutral and public standpoint. Therefore, it is suggested that basic municipalities should actively restrict implementation in locations where the public perception is that the negative impacts will be substantial and avoid unreasonable opposition to these locations due to the NIMBY phenomenon.

4. Materials and Methods: Survey Design and Implementation

4.1. Methodology

We conducted a socio-spatial analysis. We followed the methodology of Zoellner et al. [41], who adopted a social-science approach and studied the public acceptance of renewable energy. We also referred to the methodology of Devine-Weight and Howes [42], who analyzed the place attachment and negative reactions to renewable energy, consisting of qualitative and quantitative surveys. They used a questionnaire survey to identify the factors behind the negative reaction in the study area. In this study, we also employed a questionnaire survey for qualitative analysis and employed GIS analysis for a quantitative survey to identify the location trends in solar power across the country.

A socio-spatial analysis is divided into social and spatial analyses. Here, a social analysis was conducted by surveying local governments regarding their awareness of solar power generation problems. The spatial analysis was conducted by a location analysis of solar power generation using GIS. The socio-spatial analysis was completed by integrating and examining these social and spatial analyses.

For the questionnaire survey, we targeted local governments across Japan to clarify the problems the public had with renewable energy. For the quantitative survey, we created an original dataset on the location of the renewable energy facilities, specifically solar panels, and clarify where the issues of the “solar rush” are aggregated by focusing on the landscape changes. As will be described later in detail, as a result of the quantitative analysis, the Ibaraki Prefecture, which is a peri-urban agricultural area in the suburban Tokyo metropolitan area, was identified as being clearly affected by the solar rush. Therefore, the Ibaraki Prefecture was used as the case study for detailed analysis. Finally, we present policy recommendations toward conflict management that can be utilized by the local community to realize sustainable renewable energy developments that can coexist with the local communities.

The method employed here drew on the work of Zoellner et al. [41], who adopted a social-science approach to study the public acceptance of renewable energy. Their study consisted of qualitative and quantitative methodologies. They conducted interviews for the qualitative surveys and questionnaires for the quantitative surveys. When creating our questionnaire, we also referred to the Devine-Weight and Howes methodology for research, which analyzed place attachment and negative reactions to renewable energy [42]. For this study, we used questionnaires and interviews for the qualitative surveys and GIS-based analysis regarding the location changes for solar power for the quantitative surveys. From the questionnaire survey result, we extracted the common issues surrounding the solar power locations that were recognized from a public and neutral standpoint. From the location analysis results, we determined the “solar rush” characteristic locations. As a spatial-social approach, the issues of the solar rush could be comprehensively clarified from both the problem recognition for the local government and the spatial analysis.

4.2. Data Collection

4.2.1. Qualitative Survey with Questionnaires and Interviews of the Local Governments

Awareness of the issues of solar power was captured in two types of surveys. The first one was an interview survey targeting local governments in which conflicts occurred, and the other was a questionnaire survey targeting local governments nationwide. An interview survey was also conducted as a preliminary survey to set the question items in the questionnaire survey targeting local governments nationwide. The target municipalities for the interview were extracted in two ways. The first one includes four local governments from the Shizuoka Prefecture. The Shizuoka Prefecture has Mt. Fuji and the tea plantations, which are the representative landscapes of Japan. The prefectural government has set up a committee to consider solar power issues. We received cooperation from local governments near the tea plantation and Mt. Fuji. The others are municipalities in which lawsuits have been filed between local residents and solar power companies. We cooperated with the four municipalities. The interviews revealed that conflicts intensified in small municipalities that did not have a land-use regulation authority. In large cities with special land-use rights, solar power facilities are usually positioned as factories and are located near industrial areas. However, small municipalities in the suburbs and rural areas do not have a land-use authority and have almost no industrial zones. Consequently, it was found that solar power was randomly located in farmland and mountains in small local governments other than urban areas, causing major conflicts with the local communities. From the interviews, it was found that the following concerns were raised by local governments regarding the location of solar power: landscape destruction, increased risk of landslide-related disasters when panels are installed on slopes, and the quality of electricity supplier management.

Based on the results of the interview survey, we selected the target area for the questionnaire survey. In Japan, large cities, such as prefectural capitals, have special land-use regulation powers. There are 68 large-scale municipalities with special authority regarding land-use regulations. Therefore, out of the 1741 municipalities nationwide, we targeted 1673 municipalities, excluding the 68 with special authority. The questionnaire was sent and returned through email in September 2017. The questionnaire recovery number was 1637, and the rate was 97.8%.

4.2.2. Quantitative Survey through Analysis of Change in Location of Solar Power in Japan

Next, we carried out a quantitative analysis of the changes in the locations of solar power to understand where the solar power generation locations were concentrated. To compare the spatial impact of the previous RPS system and the new FIT system to promote solar power, we created an original spatial dataset on the location of the solar power installations. The procedure was as follows:

(1) RPS data

The database used was the Digital National Land Information with location information issued by the Ministry of Land, Infrastructure, Transport and Tourism [43]. In this database, only RPS data as of 2014 are provided. The location and number of solar power facilities based on the RPS system and the amount of power generated were obtained from this data. Since the new solar power certification by the RPS system has been abolished from 2012, we determined that the data as of 2014 would be suitable for our analysis. The calculation procedure was as follows:

- (a) Extract the “solar power” data from the “power generation facility” data of the Digital National Land Information database.
- (b) Calculate the data with a valid “RPS certification date” (excluding data such as 9999).
- (c) As a result, 2362 solar power facilities were extracted nationwide (certification years from 2003 to 2012).

(2) FIT data

The Ministry of Economy, Trade and Industry released solar power information that was certified by the FIT system (The Ministry of Economy, Trade and Industry, 2017 [44]). They offered the name of the installer of the solar power, name of the solar power supplier, date of certification, amount of power generated, and the location of the installation. However, this is solar power information certified by the FIT system, not the actual operating information. There are a few suppliers who have only applied for a subsidy and have not actually begun the construction of the solar power facilities, to benefit from the FIT system. According to the Ministry of Economy, Trade and Industry report, by the end of 2017, only 50.6% of the solar power systems certified by the FIT system was actually operating. Therefore, a spatial analysis based on certified solar power systems may not reveal the actual conflicts that have arisen in local communities regarding the renewable energy facilities that actually have been installed (Ministry of Economy, Trade and Industry, 2018 [45]). Since this study has adopted a spatial-social approach, it is appropriate to target only the solar power facilities that are actually operating.

The National Institute of Informatics in Japan (NII) publishes the operating status of solar power on the “Electrical Japan” web page [46], led by Kitamoto [47]. Although the information provided by “Electrical Japan” includes the name of the installer of the solar power, name of the solar power supplier, address of the facility, and amount of power generated, there are no data linked to the position of the facilities. Therefore, we carried out the following work to create a database on solar power based on the FIT system in facilities that are actually operating.

- (a) Obtained information on the solar power certified by the FIT: facility name, company name, date of certification, amount of power generated, and address of the facility. The data were published by the Ministry of Economy, Trade and Industry as “business plan certification information under the FIT system”.
- (b) From “Electric Japan”, we extracted the facility name, company name, and amount of power generated by solar power that is operating under the FIT system.
- (c) Match the information in (a) with the information in (b) and extract the information that matches the facility name, company name, and amount of power generated.
- (d) Obtain the extracted facility address of (c) from data of the Ministry of Economy, Trade and Industry and convert it to GIS location information.

- (e) Obtain data on the location of the 7970 solar power facilities in operation.
- (3) Data for the Ibaraki Prefecture

As a result of the quantitative analysis using GIS, solar power increased remarkably in the Ibaraki Prefecture because of the FIT system. Based on this result, we selected the Ibaraki Prefecture for a more detailed analysis of the impact of the solar rush on land use in rural suburbs. The Ibaraki Prefecture is located at the edge of the metropolitan area and is a typical suburban area. The Ibaraki Prefecture is located in the “urban employment area” of Tokyo defined by Kanemoto; that is, at the boundary of an area where more residents commute to the center of Tokyo instead of working locally [48]. It is a typical peri-urban agricultural area. Due to the super large size of the Tokyo Metropolitan area, the prefectural center of the Ibaraki Prefecture is located 60 km from Tokyo. Besides, since it is adjacent to the Fukushima Prefecture, where the nuclear accident occurred, it is estimated that the impact of the solar rush is clearer. That is the rationale for focusing on the Ibaraki Prefecture. For a more detailed analysis of the Ibaraki Prefecture, we checked all the locations of the solar power facilities calculated from the FIT data in (2) using Google Maps.

4.3. Data Analyses

Firstly, from the results of the local government questionnaire survey, we clarified the items that local governments recognize as issues when accepting solar power and the items that they recognize as being required to be regulated. From the results of the survey, we analyzed the reasons why the public in local communities refuse to accept solar power and the measures local governments can take to address these issues.

Secondly, we analyzed changes in the location of solar panels between the RPS system and the FIT system. Sakuma et al. [30] pointed out that the introduction of the FIT system led to an increase in solar power locations in suburban and rural areas. This study also focuses on land-use changes in the suburban and rural areas due to the effects of the solar rush. Therefore, we used “Satochi/Satoyama mesh data” (Satoyama mesh data) created by Yoshioka et al. [49] and Kadoya et al. [50] to analyze whether solar panels are increasing in the suburbs and rural areas due to the introduction of the FIT system. Satoyama mesh is GIS data that is evaluated from the viewpoint of rural land use by dividing the entire country into 50-m² mesh sections. It divides all of Japan into urbanized areas and non-urbanized areas based on the actual conditions of land use. Of these, the areas excluding urban areas are divided into the following six types: “megacity suburbs”, “adjacent to urbanized areas (flat land/hilly areas)”, “adjacent to urbanized areas (in the mountains)”, “high mountain forest areas”, “rural areas”, and “rural areas (coast and remote islands)”. By comparing how many solar power facilities based on the RPS system and the FIT system are located in places that correspond to each category, we analyzed how the characteristics of the locations of renewable energy have changed.

Thirdly, the Ibaraki Prefecture as a case study area was analyzed in detail as to how the location of the solar energy installations changed due to the FIT system.

5. Results

5.1. Issues for Local Communities

5.1.1. Items Recognized as Issues

Figure 3 shows the results of the questionnaire eliciting information on the items that each local government recognized as the most serious issues related to the introduction of solar power. Multiple answers were allowed. Four items were selected as “concerns” by over 500 local governments, indicating that they are particularly important issues. Among them, landscape destruction was identified as the most serious issue (621 of the 1637 municipalities or 38% chose this answer). The second most serious issue was the increase in risks of disasters such as landslides caused by cutting down forests to

install solar power equipment. The third was the fear that electricity suppliers will not remove solar panels after the 20-year project period. This is a problem related to the reliability of the power supplier, as is the case with “Insufficient consensus building with residents” and “Insufficient management of solar panels”. It can be understood that the reliability of the power supplier is low, even in the local government. The presence of local governments as intermediaries is essential because this unreliability tends to cause conflicts between local communities and electricity suppliers. The fourth was destruction of the natural environment. It refers to protecting forests from being cut down to install solar panels. This issue is also linked to landslide disasters. Here, we will focus on the first and second issues: the increased risk of landscape destruction and landslides. These are closely related to the characteristics of the place.

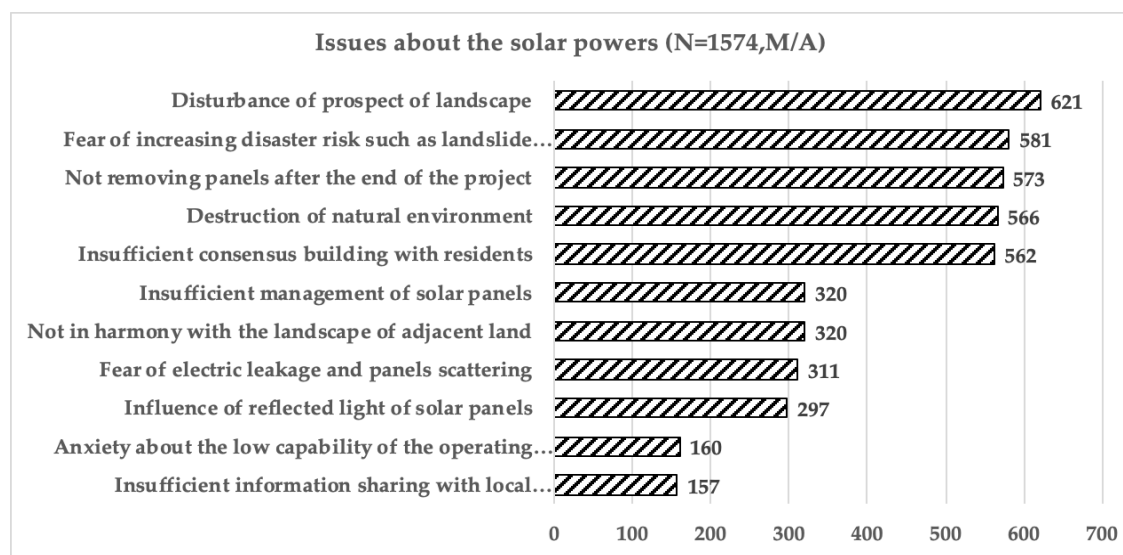


Figure 3. Survey results on the issues recognized by local governments (M/A). Source: Own survey data.

From the recognition that landscape disruption and landslides are the most serious issues related to the introduction of solar power, the following characteristics can be pointed out as places where the public perceives that there is a problem with the location of solar power facilities. First, it is a location with high visibility. For example, if the solar power equipment is installed near a residential area, the local residents will have to see it daily, even against their will. Large-scale changes in the landscape to which local residents are accustomed also would result in anger or sadness among those who are attached to the landscape. In the case of a tourist spot that boasts a beautiful landscape or nature, tourists will be disappointed if the landscape is disturbed by “artificial” solar power facilities. In rural areas where beautiful landscapes are a local resource, such facilities may disrupt the natural landscape, which may reduce tourism income. Frolova et al. [2] indicated that the artificial solar power structures contrasted considerably with the natural landscape. Secondly, if the installation is located on a slope, it is perceived to be a problem. The fact that local governments fear the risk of landslides means that the solar power facility is located on a slope. On slopes, the visibility of solar power is even higher. If it is close to residential areas, local residents would be directly at risk of a landslide. In Japan, where there are many steep mountains, large cities have been developed on a wide plain near the sea and rural villages are located in the surrounding mountainous areas. Therefore, areas with lower mountains are generally in rural areas. Therefore, it can be inferred that the location of solar power, which the local government recognizes as a problem, is on a low mountainous area close to a rural village.

Previous studies have pointed out that renewable energy has issues pertaining to the ensuing landscape change, but the current research makes it clear for the first time that public bodies

recognize renewable energy as a problem. Locations recognized by public bodies as problematic were also revealed.

5.1.2. Required Regulations

In the same survey, we asked local governments if they think regulations are needed as to where solar power installations are located. As a result, 984 out of 1637 local governments (equivalent to 60.1%) indicated that regulation was necessary. We then asked the 984 local governments what kinds of regulations or standards were needed. Items to be chosen were related to landscape, risk management, environmental conservation, and suppliers. Local governments responded to these items as either “necessary”, “unnecessary”, or “don’t know”.

Figure 4 shows the result. Many local governments answered “necessary” for most items. Of the 984 municipalities, 88.9%, i.e., 875 municipalities, said that regulations regarding landscape considerations are required. Next was consideration for the natural environment. Of the 984 local governments, 86.7%, i.e., 853 local governments, responded that it was necessary to provide regulations regarding the natural environment. From the results of our questionnaire survey, it can be understood that the locations of solar power facilities that are judged to be problematic from a public point of view are those that spoil the landscape, are located on a slope, and destroy the natural environment. In addition, it can be pointed out that the places where these three elements overlap are rural farming areas on the edge of urbanized areas. Such places are called “Satoyama” in Japan.

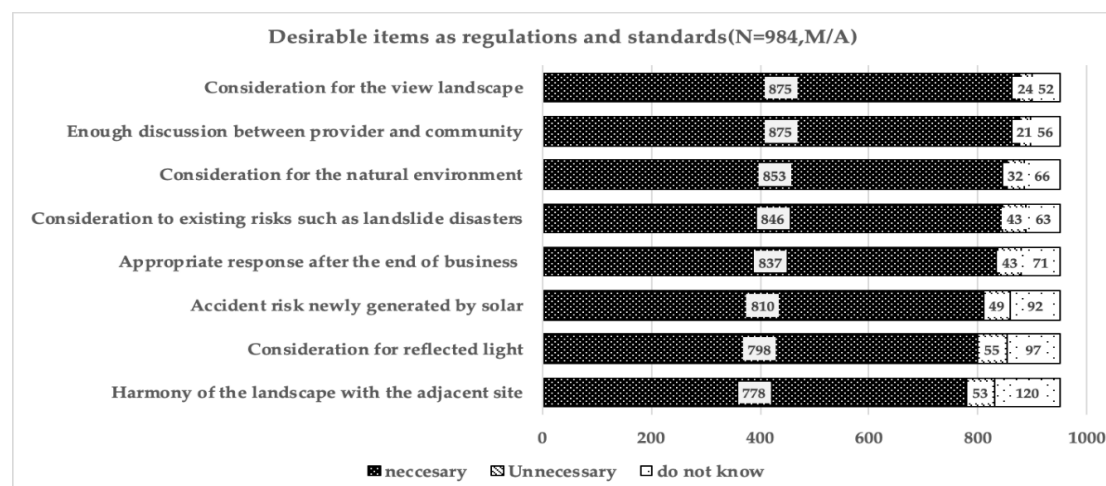


Figure 4. Items recognized by local governments to be regulated. Source: Own survey data.

5.2. Changes in Characteristics of the Location of Solar Power Facilities

5.2.1. Overview of Changes in the Location of Solar Power Facilities between RPS and FIT

As part of the spatial analysis, we analyzed how the trends in land use with solar power are changing nationwide under the RPS and the FIT systems. The location was analyzed by layering all of RPS and FIT data in Japan. We used Satoyama mesh data, which cover the whole country with a 50-m resolution on one side. Satoyama mesh was explained in Section 4.2.2. We also use the RPS and FIT point data with location information data shown in Section 4.2.2. Table 2 shows the difference in the distribution of solar power based on the RPS and the FIT systems across Japan.

Table 2. Research results: Locations of solar power based on the RPS and FIT in Japan (source: collected and processed by the authors).

Location Places		RPS (2014)		FIT (2017)	
		Locations	Percentage	Locations	Percentage
Satoyama areas	Megacity suburbs	94	9.9	61	1.4
	Adjacent to urbanized areas (flat/hilly areas)	347	36.6	1540	34.2
	Adjacent to urbanized areas (in the mountains)	260	27.4	1127	25.0
	High mountain forest areas	6	0.6	80	1.8
	Rural areas	186	19.6	1377	30.6
	Rural areas (coast and remote islands)	55	5.8	318	7.1
	Total	948	40.1	4503	56.5
Areas not Satoyama		1414	59.9	3467	43.7
Total		2362	100.0	7970	100.0

With the RPS system, 59.9% of the solar power facilities were located outside the Satoyama area and with the FIT system, 56.5% were inside the Satoyama area. With the introduction of the FIT system, solar power was brought into the Satoyama area. Looking at the breakdown of the Satoyama area, with the RPS system, the largest percentage, 36.6%, was adjacent to urbanized areas (flat/hilly areas) followed by 27.4% adjacent to urbanized areas (in the mountains). On the other hand, with the FIT system, the area adjacent to urbanized areas (flat/hilly areas) was the largest at 34.2%, but the second highest percentage was for rural areas at 30.6%. In particular, the shift from the RPS system to the FIT system resulted in a decrease in locations “adjacent to urbanized areas” and a significant increase in the proportion of locations in “rural areas”.

5.2.2. Areas Where Solar Power Is Concentrated

Next, we analyzed whether there is a regional bias in the solar power that was installed due to the introduction of the FIT system. Figure 5 is a GIS visualization of the cumulative amount of solar power installed by all of the local governments in Japan (1741 locations) in 2014 and 2017 by prefecture. The 2014 value is mainly based on the RPS system, and the 2017 value is mainly based on the FIT system. Thick black lines indicate the boundaries of the prefectures. This map shows only the solar power facilities that are actually in operation. To make it easy to understand the changes in the trends in solar power locations and visualize them with GIS, we classified the introduced power into five levels: 0 to 100 MW, 100 to 500 MW, 500 to 1000 MW, 1000 to 1500 MW, and over 1500 MW. Comparing 2014 and 2017, the amount of solar power introduced has increased in all prefectures, indicating that the solar rush hit Japan as a whole. Of particular note is that most of the orange and red prefectures, where the amount of solar power introduced in 2017 has increased rapidly, are mostly peri-urban agricultural areas near a large city.

Above all, the Ibaraki Prefecture, which is adjacent to the Fukushima Prefecture where the nuclear accident occurred, had the largest cumulative solar power generation in Japan as of 2017. Why are solar power facilities concentrated in this area? The following can be pointed out as reasons: Firstly, the availability of power transmission lines is proportional to the amount of purchased power based on the FIT system in Japan (METI, 2017 [51]). Therefore, peri-urban agricultural areas close to large cities have a relatively larger availability of transmission lines when compared to the rural areas. Secondly, the main industry in peri-urban agricultural areas, such as the Ibaraki Prefecture, is agriculture, but after the Earthquake, many farmers were at risk of losing their livelihoods. Because they had to reconstruct their farmlands, it took much time due to the progression of the ageing of the farmers. They also had to fight rumors of radiation. In response to the farmers’ demands for securing a future

income and the existence of abandoned farmland, the size of the allowable amount of electric power for the electric cables was attractive and solar power was considered to have surged in this area.

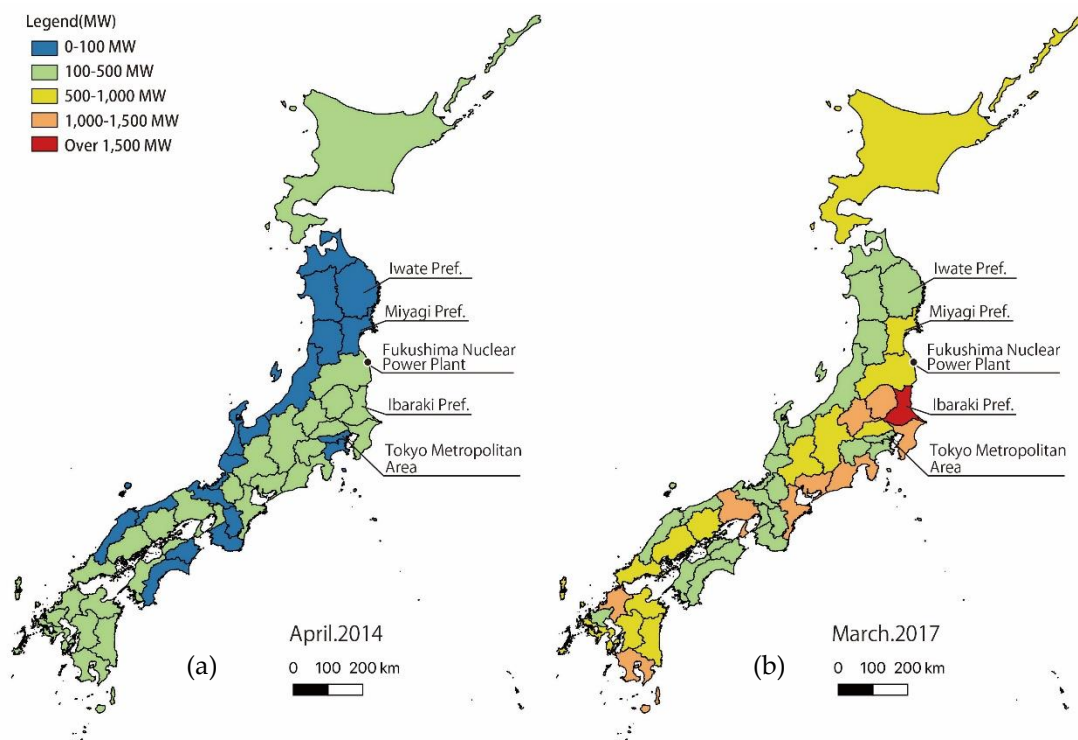


Figure 5. Changes in the cumulative number of solar power facilities in 2014 (a) and 2017 (b). Source: Collected and processed by the authors.

5.3. Case Study on the Ibaraki Prefecture

The Ibaraki Prefecture is located on the outer edge of the Tokyo metropolitan area. The center of the Ibaraki Prefecture is about 60 km from the center of Tokyo. It is a typical peri-urban agricultural area in Japan. The residents living on the south side of the Ibaraki Prefecture mainly commute to Tokyo. At the same time, the amount of agricultural production by the prefecture is the third largest in the country, and it is also a major suburban agricultural production area (Ministry of Agriculture, Forestry and Fisheries, 2020 [52]). As of 2019, the Ibaraki Prefecture had a population of 2.87 million, making it the 11th largest prefecture in Japan.

First, as described in Section 5.2.1, we analyzed how the location of the solar power facilities in the seven areas of the Satoyama Mesh Data changed from RPS to FIT. The results are shown in Table 3. In just three years, from 2014 to 2017, it became clear that a surprisingly large amount of solar power was generated through the FIT system. With the RPS system, there were only 46 solar power plants, but with the FIT system, solar power plants were installed at 657 locations, 14 times the original amount. In Table 3, the areas where the location of solar power generation has significantly increased due to the FIT system are colored in gray. The FIT system had 16 times more areas “adjacent to urbanized areas” and 39 times more rural areas compared to the RPS system. This has led to significant changes in the local landscape, especially in the “rural areas”.

Figure 6 shows the difference in the location of the solar power facilities between the RPS system and the FIT system in GIS. With the RPS system, the location of solar power was limited to one part of the Prefecture, but with the FIT system, the locations are dispersed throughout the Prefecture. It shows that the solar power installations tend to be concentrated in the southern part of the Ibaraki Prefecture, rather than the northern part. This is due to the topography. There are many high mountains in the north side of the Ibaraki Prefecture, which are far from the cities, and the population density is low. It is thought that it is difficult to install solar power generation in locations with such characteristics

in Japan. As a result, solar power will inevitably be concentrated in the gently sloping areas of the peri-urban agricultural areas at the edge of the metropolitan area.

Table 3. Locations of the solar power facilities based on the RPS and FIT in the Ibaraki Prefecture.
Source: Collected and processed by the authors.

Location Places		RPS (2014)		FIT (2017)	
		Locations	Percentage	Locations	Percentage
Satoyama areas	Megacity suburbs	0	0	1	0.2
	Adjacent to urbanized areas (flat/hilly areas)	11	25.0	180	27.4
	Adjacent to urbanized areas (in the mountains)	1	2.3	24	3.7
	High mountain forest areas	0	0	1	0.2
	Rural areas	4	9.1	156	23.7
	Rural areas (coast and remote islands)	0	0.0	4	0.6
	Total	16	36.4	366	55.7
Areas not Satoyama		30	68.2	291	44.3
Total		46	100.0	657	100.0

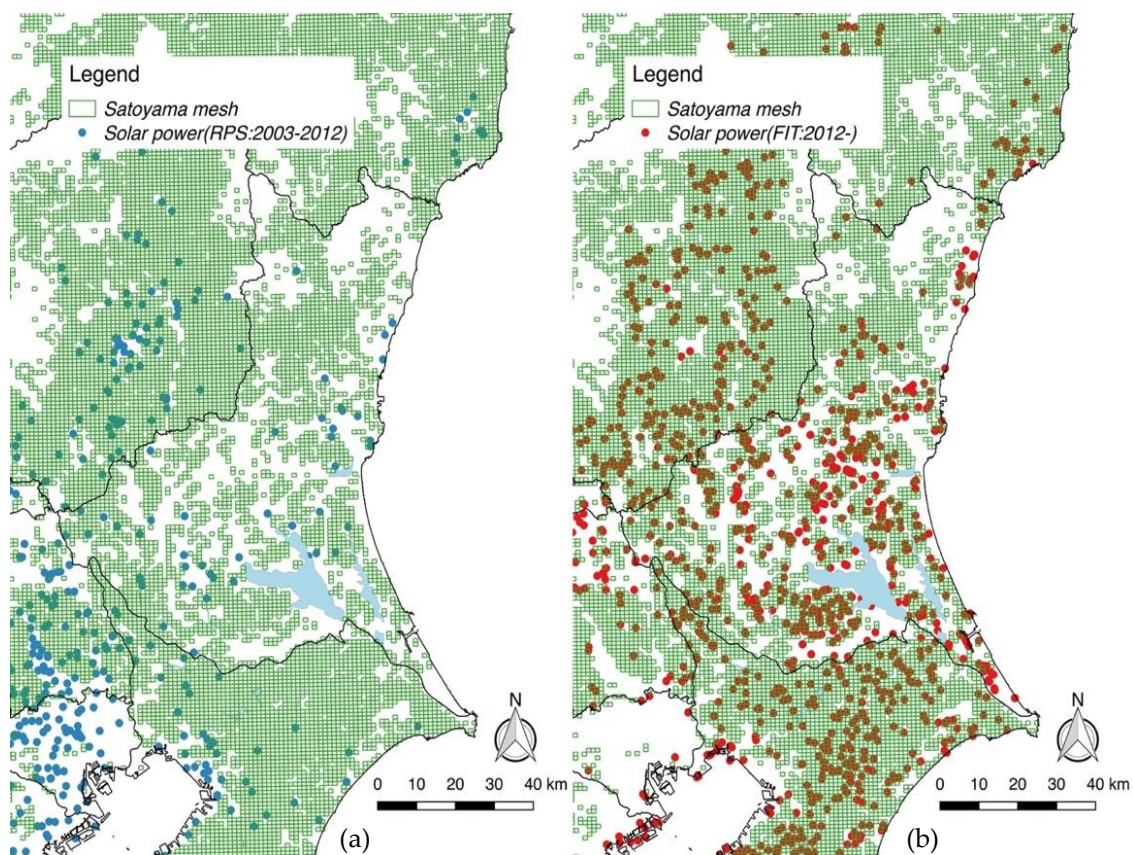


Figure 6. Location of the solar power installations in 2014 by RPS (a) and 2017 by FIT (b). Source: Collected and processed by the authors.

6. Discussion: Conflict Management

The results of our research revealed that the introduction of the FIT system in Japan caused a concentration of solar power in peri-urban agricultural areas. In addition, it became clear that

solar power was often concentrated in areas with a mountain slope near residences. In such places, the inhabitants did not expect the enduring landscapes to change. The most affected area was the Ibaraki Prefecture, which is located on the edge of the Tokyo metropolitan area adjacent to the Fukushima Prefecture, where the nuclear accident occurred. With the introduction of the FIT system, a large number of solar power facilities, which is 23 times that with the RPS system, were established in the rural area of the Ibaraki Prefecture in just three years.

In the Ibaraki Prefecture, a solar power supplier had applied for a location for solar power that was not only an agricultural area but also a plum garden on the slope of Mt. Tsukuba. The plum garden is a beautiful landscape feature of which the Ibaraki Prefecture and the local community are proud. In response to this application, the Ibaraki Prefecture has decided not to allow it in order to protect the beautiful landscape of the plum garden on Mt. Tsukuba and not increase the risk of landslide disasters. However, the supplier filed a lawsuit against the Ibaraki Prefecture as a defendant, and finally the Ibaraki Prefecture was defeated in 2018. Immediately after the judgment, Tsukuba City, the local municipality where Mt. Tsukuba is located, enacted an ordinance about the appropriate location of solar power installations. The ordinance specifies important areas of the landscape, such as Mt. Tsukuba, as prohibited areas for solar power. The ordinances and standards adopted by Tsukuba City articulate local values and local ethics. Respect for these local values and ethics will be essential in the introduction of renewable energy. Through accumulating good practices by such local governments, the Ibaraki Prefecture is trying to protect its own landscape and establish a symbiosis between local communities and solar power. Wolsink [53] also pointed out that local involvement to represent the local values of site-specific landscapes is crucial. Torres-Sibille et al. [21] proposed a tool for identifying the correct location of economic activity within a region based on a quantitative assessment of the environmental and social impacts.

The empirical results indicate that the term “landscape” used by local communities and local governments does not only refer to beautiful scenery but also reflects the local industry, such as farming, the places at which activities of daily living are carried out, and sites for social activities of communities and residents. The word “landscape” is used as a comprehensive concept that describes the activities and lifestyles of suburban agricultural areas. That is why local communities recognize that the reason for conflict with regard to renewable energy encompasses more than the appearance of a local community but the internal qualitative changes within that community as well.

We believe that policy interventions will be necessary to solve these social conflicts. Renewable energy cannot be generated separately from locally specific resources and the local environment. Renewable energy can basically be obtained from the natural benefits of the area, such as the sun, wind, and geothermal energy. This is the same for suburban agriculture. In this way, it can be said that agriculture and renewable energy are in competition over land in peri-urban agricultural areas. Therefore, renewable energy suppliers need to share the benefits of the land with the local community. For a stable supply of renewable energy based on local land, it is essential for suppliers to find ways to build good relationships with the local community. The UK is studying the potential of renewable energy to form good relationships with local communities [54]. Warren [55] pointed out a positive psychological impact on community-owned wind power in Scotland. Naveh [56] proposed that renewable energy projects should follow the principles and guidelines of “holistic landscape ecology”. Renewable energy suppliers need to find ways to coexist with agriculture, which is the main industry in the area, and improve local landscapes and revitalize local communities. The FIT system allowed anyone to become a solar power provider as long as they own the land. As a result, countless individuals and small businesses are increasingly leasing small plots of farmland for solar power, and it is difficult to know who owns the land and who installed the solar panels. Generally, most solar power providers are outsiders of the local community and they are not familiar with the local rules. This creates a conflict. Thus, conflict management at the local governmental level is essential to achieve this goal.

7. Conclusions

Understanding the impact and public responses to diverse scales of renewable energy projects is of academic and practical importance, given the policies to decrease fossil fuel use in many countries. Therefore, research that is focused on the acceptance of renewable energy by local residents has been conducted by the international academic community. For example, Devine-Wright and Howes [42] conducted a case study in the UK to analyze the opposing factors of renewable energy among local people, focusing on their attachment to the area. As a result, it became clear that the attachment to the area and opposition to renewable energy were not necessarily linked. Research on the design of renewable energy that is acceptable by local residents has also been actively conducted [1,4,5,21–23]. Oudes et al. [57] proposed a method to reduce stakeholder conflicts with the introduction of renewable energy by using a spatial transition analysis. Through a case study in Germany, Zoellner et al. [41] argued that to further expand renewable energy utilization, an increasing support for concrete energy systems on the local level is needed. They also concluded that, in order to reach “local” acceptance, the influencing factors and specific regional distinctions and needs have to be considered. The results of this Japanese case study also support these discussions. This study finds that the influencing factors have geographical characteristics and that conflict management by local governments is effective in controlling the impact. The acceptance of renewable energy in the community is a common international issue. The results of this research offer insights into where issues tend to be concentrated.

In conclusion, our findings validated the initial hypothesis that spatial characteristics are important factors that contribute to conflicts between communities and renewable energy projects. The empirical results of the questionnaires and interviews with local governments revealed that the issues regarding the introduction of renewable energy, from a public and neutral standpoint, concerns the destruction of landscapes and the increased risk of landslides. The GIS analysis of the changes in the location trends showed that the solar power locations had polarized; that is, on a regional scale, solar power facilities are located in the peri-urban agricultural area of a large city. On a local scale, they are located along small mountain slopes behind settlements. In the Ibaraki Prefecture, which is a typical peri-urban agricultural area, this tendency was noticeable. This shows that in the peri-urban agricultural areas, agriculture and solar power compete for land. This is the novel and most important finding of this study. A surge in renewable energy related to land use, such as the solar rush, may accelerate the decline in agriculture due to a reduction in agricultural land, which is a major industry in the region. Prior to the solar rush, existing local industries and land use had to be adjusted. These situations demonstrate the rationale for local governments to undertake conflict management, if they are able to understand local values and ethics.

This study had some limitations. First, this study does not analyze the long-term direction of renewable energy in Japan since it focuses on the factors behind the surge in solar power just after the Great East Japan Earthquake of 2011. In fact, the Japanese government is gradually reducing the purchase price of solar power in order to cope with the disruption of local communities and landscapes caused by the location of solar power facilities. The effects of these new systems are not mentioned in this study. Secondly, this study focused only on the location of the solar power installations, and we have not been able to evaluate its comprehensive impact, such as its economic effect. The economic evaluation that renewable energy gives to the local community is still in the process of research, and further research is necessary [58]. Thirdly, the effectiveness of conflict management should be fully investigated within the areas where conflicts are occurring. Therefore, the roles of local governments should be further pursued toward the sustainability of peri-urban agricultural areas. In order to achieve this objective, it is essential to consider the support measures of the central government and prefectures. We believe that conflict management has the potential to become a new planning theory that replaces consensus building in accordance with today’s diverse values. A further study of conflict management should be conducted.

Author Contributions: Conceptualization and methodology, N.A. and Y.O.; resources, N.A., T.T. and J.B.; writing—original draft preparation, N.A.; writing—review and editing, Y.O.; investigation, N.A. and S.A.; supervision, M.Y.; project administration, N.A.; and funding acquisition, N.A. All authors have read and agreed to the published version of the manuscript.

Funding: This work was partly supported by the JSPS KAKENHI Grant Number JP19H02308. The corresponding author carried out the “Survey on landscape guidance policy of solar powers in harmony with natural environment in Shizuoka prefecture”, granted by the Ministry of Land, Infrastructure, Transport and Tourism in 2017. A part of this research result is reflected in this paper.

Conflicts of Interest: The authors declare no conflict of interest.

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