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Exploring public engagement and social acceptability of geothermal energy in the Philippines: A case study on the Makiling-Banahaw Geothermal Complex

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ABSTRACT

The Makiling-Banahaw Geothermal Complex was one of the first two geothermal projects for exploration and development in the Philippines. The study aims to identify critical issues and supporting factors for geothermal energy projects in the Philippines by collecting and analyzing qualitative and quantitative data from various stakeholders of the Makiling-Banahaw Geothermal Complex. The case study reveals that stakeholders of *barangays* with geothermal facilities were agreeable to geothermal energy. Frequent periodic and strategic public engagement initiated by geothermal resource developers and local government can develop trust and improve integration of geothermal energy with the local communities.

1. Introduction

1.1. Geothermal energy in the Philippines

Electricity is an essential component of day-to-day living as well as an indispensable resource which strongly correlates to economic development (Ferguson et al., 2000). To contribute in solving the universal problem of increasing demand for electricity and decarbonizing energy supply, renewable energy resources are being promoted by several international agencies and organizations such as United Nations Framework Convention on Climate Change (United Nations, 2015). This stresses further the necessity to tackle sustainability issues of renewable energy resources from their production, transmission and utilization.

Energy transition and renewable energy technologies, either in the planning stage or development stage, have faced opposition and have raised complex issues for stakeholders such as policy-makers, geothermal resource developers, and local communities (Pellizzone et al., 2017). The Philippines, as one of the world's top producers of geothermal energy, has an installed capacity of 1944 MW (Department of Energy, 2018). The exploration projects on geothermal energy for electricity started in 1962 and its development was accelerated in the 1970s due to the worldwide oil crisis (Ratio et al., 2019). The privatization of state-owned power generation assets started in the 2000s with the passing of a law to deregulate the industry to break state monopoly (Ratio et al., 2019). Geothermal energy development goes beyond technical issues and requires perspective under the critical lens of social science studies. Various social dimensions of technology such as economic, political, financial, and public engagement have been identified in case studies from a number of countries with potential for large-scale geothermal power generation (Carr-Cornish and Romanach, 2012; Ehara, 2009; Erdogdu, 2009; Hall et al., 2013; Kelly, 2011; Mariita, 2002; National Power Corporation—Philippine Geothermal, Inc., 1998; Noorollahi et al., 2009; Phillips, 2010; Purkus and Barth, 2011; Taleb, 2009). The exploitation of geothermal energy is viewed as a technical problem. However, its adoption and evolution are driven by interacting social, political and institutional factors (Bijker et al., 2012; Jónsson et al., 2019). New Zealand has recognized early on the social effects of geothermal resource development and issues arising from non-inclusion of native people in the decision-making process (Stokes, 2000; Tutua-Nathan, 1988). There is growing research interest in the social aspect of sustainable energy technology across different countries, particularly in the geothermal sector compared to other renewable and non-renewable energy, based on the number of academic papers in the last decade (2008–2018) (Manzella et al., 2019).

Renewable energy projects, such as geothermal energy, require several interconnected infrastructures such as social, political and economic systems in order to progress their development (Pidgeon et al., 2014; Stirling, 2014). Public support has been often compromised or least prioritized in renewable energy development projects. To

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further reinforce its importance, the United Nation Paris Agreement entered into force on November 2016 aimed at progressing towards sustainable development. The commitments in greenhouse gas reduction can be addressed by developing renewable energy sources and energy efficiency (United Nations, 2016). Public engagement and citizens' participation have an increasing importance in decision-making process for renewable energy transition (Allansdottir et al., 2019). The Philippines, which is a member of the Global Geothermal Alliance (GGA) launched at the 21 st Meeting of the Conference of the Parties of the United Nations Framework Convention on Climate Change, is a partner of this platform for enhanced dialogue, knowledge sharing, and coordinated action to increase the energy share of installed geothermal electricity (Manzella et al., 2019). In September 2017, this commitment has been reaffirmed by the member governments to implement measures to significantly increase the speed of geothermal energy development under the terms of the Florence Declaration of the Global Geothermal Alliance (Global Geothermal Alliance, 2017).

In the Philippines, the Makiling-Banahaw Geothermal Complex was one of the first two geothermal projects for exploration and development with a total installed capacity of 458.53 MW (Asian Development Bank, 2015). The proximity to the capital, relatively flat terrain, and low altitude are its unique features in contrast to geothermal plants located in mountainous high-altitude areas. Its convenient accessibility and location are attractive for in-migration due to the improvement of economic condition.

Despite geothermal energy exploration since the 1960s and the continuous operation of Makiling-Banahaw Geothermal Complex for more than 30 years, there has been no published baseline studies on social acceptance about the geothermal project. The history of geothermal energy development and geothermal power operation can be a source of information for investigating the principal barriers and deciding factors toward harmonious integration of renewable energy and society in the Philippine setting.

Renewable energy, such as geothermal, is an innovation aimed at addressing social challenges such as energy sustainability. In order to advance inclusive geothermal development, meaningful engagement with the stakeholders is very significant. The study aims to identify critical issues and supporting factors for geothermal energy projects and to assess the condition of stakeholder engagement by collecting and analyzing qualitative and quantitative data from various stakeholders of the Makiling-Banahaw Geothermal Complex.

1.2. Makiling-Banahaw Geothermal Geothermal Complex

Located in the boundary areas of the provinces of Laguna and Batangas, the Makiling-Banahaw Geothermal Complex is located about 74 km south of Manila. In a unique geopolitical position, it is situated in three municipalities with some portions overlapping with the Makiling Forest Reserve. The Makiling-Banahaw Geothermal Complex is classified as a geothermal development project for the exploration, development, exploitation, and utilization of geothermal energy, natural gas and methane (NPC-PGI, 1998). The 1620 sq. km-area in the vicinity of Mt. Makiling was declared as a geothermal reservation area by the Presidential Proclamation No. 1111 of 1977. The Special Zone for Geothermal Development covers 11 barangays (*barangay* refers to the smallest administrative division in the Philippines): nine in Santo Tomas, Batangas (Barangays San Felix, San Pedro, San Vicente, San Miguel, Santa Elena, San Jose, San Bartolome, San Pablo, and San Juan); one in Bay, Laguna (Barangay Bitin); and one in Calauan, Laguna (Barangay Limao) (Fig. 1).

The Special Zone for Geothermal Development in the Makiling-Banahaw Geothermal Complex is composed of three major sub-zones: production zone, buffer zone and pipeline security corridor. The production zone covers the whole of Barangay Bitin (Bay, Laguna) and parts of Barangay Santa Elena and Barangay Limao. As confirmed by electrical resistivity surveys, the resistivity anomaly boundaries coincide with this production zone (Capuno et al., 2010; Clemente and Villadolid-Abrigo, 1993). This area was designated and intended for the production of steam including the well pads and power plant infrastructures. On the eastern and western sides of the production zone, the wellheads are located in Barangay Limao (Calauan, Laguna) and portions of the barangays in Santo Tomas, Batangas. Its 97.4-km steam pipeline passes through mostly agricultural lands. The buffer zone aims to restrict land development to assure safety of the environment and the community. The pipeline security corridor is exclusively for steam pipes. The Entire Impact Zone extends one kilometer from the boundary of any and all parts of the geothermal facilities (NPC-PGI, 1998). Steam pipes and power plant infrastructures are hosted within five barangays: Santa Elena, San Felix and San Jose (Santo Tomas, Batangas); Barangay Bitin (Bay, Laguna); and, Barangay Limao (Calauan, Laguna) (Table 1) (Butardo-Toribio et al., 1995; Echavez, 1997). Eighty percent of the entire geothermal facilities and infrastructures are in Barangays Santa Elena, Bitin and Limao.

In the Philippines, claim of land ownership is constituted by acquisition of titled land and possession of said land. On the other hand, the law considers a person who settle on private or public land without a title, right, or consent from the private land owner or concerned government authority as an informal settler. In the Special Zone of the Makiling-Banahaw Geothermal Complex, there are no indigenous peoples and indigenous cultural communities occupying nor possessing ancestral domains. For this study, both private land owners and informal settlers residing within the Special Zone are considered stakeholders whose quality of life may be positively or negatively affected by the geothermal operations and facilities. Being situated in easily accessible provinces from the capital, the Special Zone for Geothermal Development transformed into rapid commercial and industrial development areas (NPC-PGI, 1998). In the early 1980s, there was a big influx of population in the area because of the employment opportunities and provision of infrastructure and service facilities (i.e. cemented road, free water, electricity among others) offered by the Makiling-Banahaw Geothermal Project (Butardo-Toribio et al., 1995; Philippine Statistics Office, 2016).

The government revenue generated from the utilization and development of national wealth (e.g. minerals, timber among others) is collected by the government agency (i.e. Bureau of Internal Revenue under the Department of Finance) from the geothermal resource developers. The allocation of shares from the national tax is determined by the Local Government Code of 1991 to each level of the local government units (i.e. Province, Municipality/City and Barangay), respectively (Ratio et al., 2019). At least 80 % of the proceeds from the share shall be applied to lower cost of electricity in the local government unit and the rest shall be appropriated for local development and livelihood projects. In addition, the geothermal resource developers provide scholarships, medical health missions, and education campaigns. A perception survey on the implementation of National Power Corporation's Social Development Program in 2006 mentioned that communities around the geothermal area acknowledged the numerous benefits such as employment, free medical and dental services, school scholarships, and alternative livelihood trainings (Asian Development Bank, 2015). However, there were other issues within the geothermal zone, particularly encroachment near steam pipes. The expansion of the proposed industrial area generated financial opportunity for landowners to convert the farmlands into light industrial area. The conversion of land use indicated decreasing land area for agricultural use (Municipality of Santo Tomas, 1997).

The main hazards in the study area are flooding, induced seismicity, and land subsidence. According to the Makiling-Banahaw Comprehensive Land Use and Development Study, several sites experienced flashfloods especially during heavy rains and these were attributed to inadequate drainage facilities, clogging of the system, and decreasing capacity of the conveyance channels due to accumulation of domestic wastes (NPC-PGI, 1998). Quarrying activities which resulted

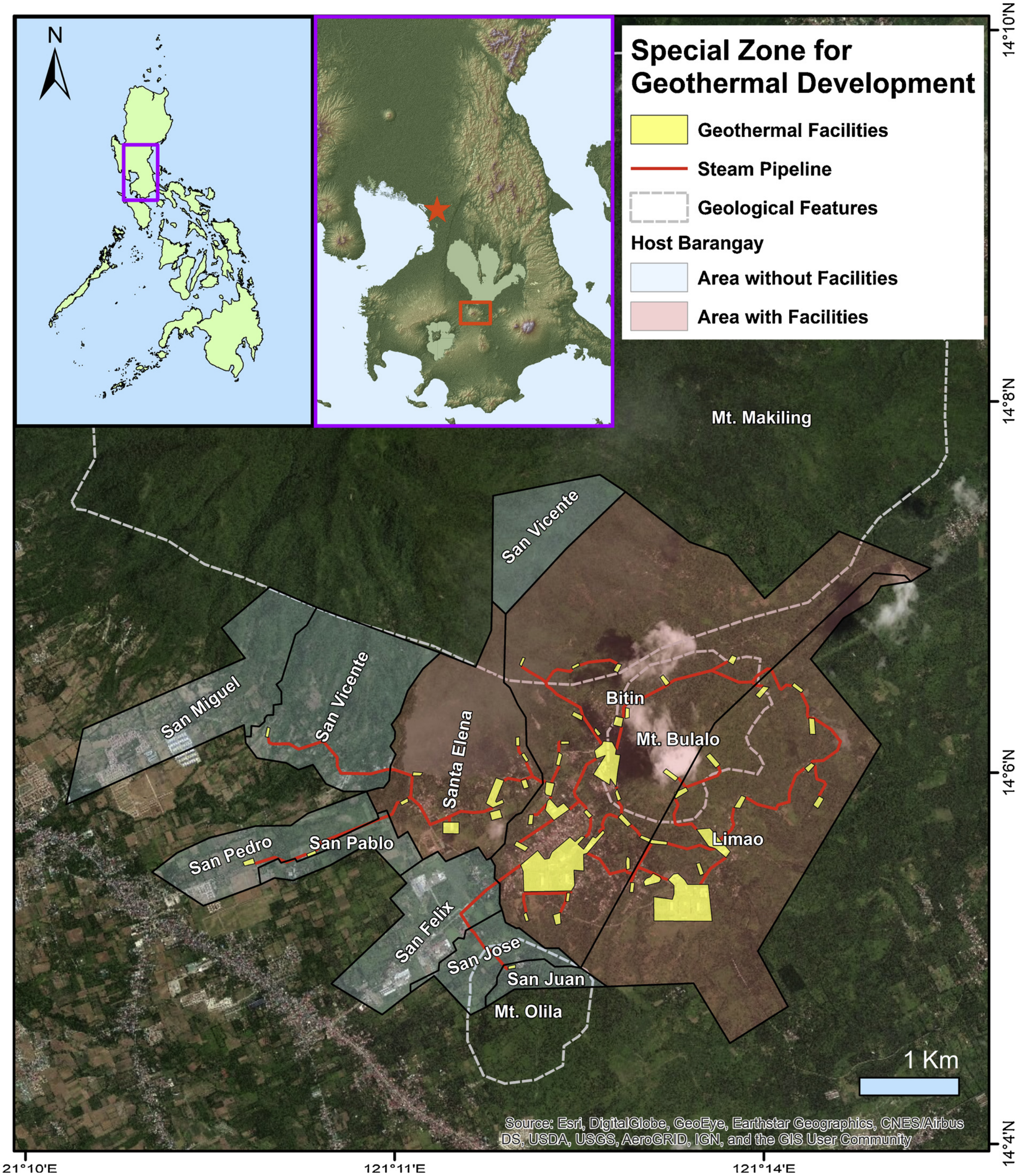

Fig. 1. Map of Makiling-Banahaw Geothermal Development Zone and the barangays under study within the zone. The size of area of Barangay San Bartolome is negligible in the scale of the map. The satellite image shows dense residential area proximate to the geothermal facilities.

in forest denudation and heavy siltation are being blamed for flooding in other parts of the area. While risks of induced microtremors and land subsidence bothered the local communities, the local government urged geothermal resource developers to inform the public regarding the result of their monitoring.

2. Literature review

The classic concept of social acceptance is defined as the level of support or opposition to renewable energy that results from the interaction of attitude, values, beliefs, knowledge and opinion of individuals and groups (Stephenson and Ioannou, 2010). The social acceptance of renewable energy has been understood to have dimensions such as socio-political acceptance, community acceptance, and market acceptance (Devine-Wright et al., 2017; Wüstenhagen and Menichetti, 2012; Wüstenhagen et al., 2007). Recognizing the significant factors that influence social acceptance is important in the implementation of energy policies in relation to the development of renewable energy systems. Furthermore, social acceptance and consensus building are considered major influences in the viability of renewable energy emerging technologies (Dowd et al., 2011). Renewable projects can progress faster with proper understanding of public engagement dynamics (Assefa and Frostell, 2007; Devine-Wrigth, 2007; Pellizzone et al., 2015; Rogers et al., 2008). Low levels of social acceptance may pose challenges for

Table 1
Electric power plants of Makiling-Banahaw Geothermal Complex.

Unit	Plant	Installed Capacity (MWe)	Date Commissioned	Location (Barangay/Municipality/Province)
1	A	63.20	1979-04-26	Barangay Bitin, Bay, Laguna
2	A	63.20	1979-07-25	Barangay Bitin, Bay, Laguna
3	B	63.20	1980-04-22	Barangay Limao, Calauan, Laguna
4	B	63.20	1980-06-25	Barangay Limao, Calauan, Laguna
5	C	55	1984-06-05	Barangay Limao, Calauan, Laguna
6	C	55	1984-09-10	Barangay Limao, Calauan, Laguna
7	D	20	1995-10-16	Barangay Bitin, Bay, Laguna
8	D	20	1995-11-12	Barangay Bitin, Bay, Laguna
9	E	20	1996-05-22	Barangay San Felix, Santo Tomas, Batangas
10	E	20	1996-05-27	Barangay San Felix, Santo Tomas, Batangas
Binary Plant: Makiling-Banahaw Ormat Plant		3	1994-02-28	Barangay Bitin, Bay, Laguna
		3	1994-02-28	Barangay Bitin, Bay, Laguna
		3	1994-02-28	Barangay Bitin, Bay, Laguna
		3	1994-02-28	Barangay Bitin, Bay, Laguna
		3	1994-02-28	Barangay Bitin, Bay, Laguna
		0.73	1994-02-28	Barangay Bitin, Bay, Laguna

renewable energy and improving it may contribute to a higher share of renewable sources in power generation.

Opposition or support of certain energy sources, whether renewable energy or conventional sources such as nuclear power, are greatly reliant on perceived risks and benefits (Hunter and Leyden, 1995; Visscher and Siegrist, 2013). The trust towards developers and institutions is important in the perception of risk and benefit derived from renewable energy development (Carr-Cornish and Romanach, 2014; Visschers and Siegrist, 2013). Greenberg (2014) conceptualizes the elements of trust as confidence directed to actors in energy development and social trust as possessing values consistent with the public. Neglecting the necessity to integrate with the stakeholders, especially the local residents, or poorly executed dialogues and mismanaged communication processes, escalate concerns on social acceptance which lead to opposition, financial losses, and social conflicts (Jobert et al., 2007; Pidgeon and Demski, 2012). The failures of resource developers to integrate the project with the communities convey an impression of unworthiness and opportunistic behaviors (Rizzi and Frey, 2014). Regardless of whether a renewable energy project such as a geothermal energy development project has very similar technical designs, social acceptance of each project could exhibit significantly different outcomes (Brohmann et al., 2007).

There are several factors that can impact the opposition or support towards emerging renewable energy technologies. A prominent factor is socio-demographic characteristics as exhibited by studies on public support or opposition to energy and non-energy technologies (Polyzou and Stamataki, 2010). While sex is found to have been strongly linked with social acceptance, males are more likely supportive of emerging technologies due to lower perception of risk (Ansolabehere and Konisky, 2009).

Social acceptance is a main issue that affects the pace of the development of renewable energy projects and energy policy objectives (Alasti, 2011; Wüstenhagen et al., 2007). Debate on social acceptance for renewable energy innovation includes siting decisions since renewable energy sources are usually smaller in scale than conventional power plants which tend to be characterized by lower energy densities (Ansolabehere and Konisky, 2009; Menanteau et al., 2003; Pidgeon and Demski, 2012; Stephenson and Ioannou, 2010; Zoellner et al., 2008). The geographic location and proximity of the residents would affect living conditions and lifestyle in the area, hence, it was found to have significant impact on social acceptance (Hall et al., 2013; Huijts et al., 2012). Cultural value or personal attachment to particular rural landscapes or their so called "backyard" are found to be conflicting with potential project developments in the area and associated with losses of landscape (Ekins, 2004; Hall et al., 2013; van der Horst, 2007). Site selection based only on the technical characteristics can elicit preexisting skeptical beliefs and distrust among the stakeholders especially towards geothermal resource developers (Stephenson and Ioannou, 2018). Economic interest in relation to renewable energy sources, such as being shareholders or investors, provide significant reasons for stakeholders to have sense of ownership and social participation (Krohn and Damborg, 1999; Maruyama et al., 2007). Tangible benefits for the local communities, such as livelihood activities and scholarships, can also improve public support (Cataldi, 1999). The importance of socio-economic aspects is recognized as "more important than technical ones" in persuading people to adopt renewable energy technologies (Yun and Lee, 2015). There is a need for resource developers to significantly consider the role of local stakeholders and end-users in promoting geothermal energy (Contini et al., 2019).

However, more recent studies have acknowledged that the concept of "backyard" is problematic. The Not-In-My-Back-Yard (NIMBY) concept has been used as a reason for opposition to facility siting, but has been critiqued on several grounds (Devine-Wright, 2011; Wolsink, 2000). While NIMBY is often viewed as the spatial explanation for local resistance to siting, literature on facility siting and decision-making process renders this concept inadequate because it assumes home-to-site proximity to be the major factor influencing response (Devine-Wright, 2009; Jones and Eiser, 2009; Wolsink, 2000). The NIMBY pejoratively labels people who oppose development and also views their sentiments as selfish motives impeding societal goals (Burningham, 2000; Devine-Wright, 2009; Wolsink, 2000).

Devine-Wright (2009) proposes a new framework rethinking NIMBY as place-protective action, arising from introduction of new development that disrupts pre-existing emotional attachments and threatens place-related identity. Place attachment has been defined as both the process of attaching to a place and the product of this process (Giuliani, 2003). On the other hand, place identity refers to the ways in which physical and symbolic attributes of certain locations contribute to an individual's sense of self or identity (Proshansky et al., 1983). The impact of change or new development, sometimes labelled by literature as 'disruption' to place attachment or 'threat' to place identity, affects not only the physical aspect but also the social networks (Devine-Wright, 2009; Speller and Twigger-Ross, 2009) leading to diverse coping responses such as place-protective behaviors (Stedman, 2002). As an alternative to the NIMBY concept, place-related meanings and attachments have a positive relationship with acceptance of development (Devine-Wright, 2011).

Various concepts regarding social acceptance have been developed to put important emphasis on stakeholder engagement. The deficit model or "Scientific Literacy Paradigm" from the 1960s to mid-1980s presumes a public deficient in knowledge, attitude, or trust (Bauer et al., 2007). The deficit model presupposes that the insufficiency is

Table 2
The details of the interview.

Interviewees	Affiliation	Group
Member of Board of Trustees	National Geothermal Association of the Philippines	NGO
Campaign Coordinator	Greenpeace Southeast Asia	NGO
Programme Head	WWF-Philippines	NGO
Ecology and Environmental Science Professor	University of the Philippines Los Baños	Academe
Municipal Planning Officer	Municipality of Bay, Laguna	Local Government Unit
Municipal Planning Officer	Municipality of Calauan, Laguna	Local Government Unit
Division Chief	Renewable Energy Management Bureau, Department of Energy	National Government Agency
Public Affairs Officers	Philippine Geothermal Production Company, Inc.	Geothermal Resource Developer

with the public (on knowledge and positive attitude about science). However, the paradigm ultimately shifted to "Science and Society", in which the deficit is recognized to be from the expert actors and scientific institutions who prejudiced the public (Bauer et al., 2007). The "Science and Society" viewpoint necessitated a re-negotiation of the social contract amidst the crisis of public trust vis-à-vis science. Wilsdon et al. (2005) emphasized the need for upstream public engagement implemented throughout the complex and varied stages of technoscientific developments.

Moreover, Owen et al. (2012) introduced the framework programme "Responsible Research and Innovation" which called for greater public engagement for science and technology. He emphasized that research and innovation should focus on addressing societal challenges. Ethically problematic areas of science and innovations can only be undertaken through an interactive process between mutually responsive scientific innovators and societal actors (Grove-White et al., 2000; von Schomberg, 2014). Owen et al. (2012) further stated that through collective deliberation (i.e. processes of dialogue, engagement and debate), the wider perspectives from diverse stakeholders can be integrated with science and innovation. Meaningfully engaging the public and ensuring trust start with the common understanding between the scientific innovators and societal actors that "research and innovation are not separate to society" (Mazzucato, 2019). The formal consultations and direct interaction with stakeholders in every stage of a technoscientific development are required to advance science and technology to solve societal challenges.

Concern with environmental problems, knowledge about renewable energy sources, and belief in their effectiveness are attitudes and perspectives toward renewable energy technologies. These are not always translated as concrete representations of an individual's support for it unless they are willing to financially contribute to it (Liu et al., 2013). Risk and benefit perception, and opinions and attitudes towards renewable energy technologies are influenced by mass media regardless of the absence of relevant scientific or policy-related information (Stauffacher et al., 2015). Corporate social responsibility and focus group discussion are tools for promotion strategies which are found to significantly change citizens' opinion to accept and use geothermal energy (Carr-Cornish and Romanach, 2014; Contini et al., 2019). The combination of formulating information strategies and fostering trustworthy relationships should allow resource developers to push geothermal energy adoption based on integrating with the community's needs (Contini et al., 2019). Consumer knowledge can be reinforced through information-based campaigns which will concretize willingness to pay for renewable energy implementation (Bang et al., 2000).

A study on geothermal energy development revealed that similarly designed geothermal projects could result in distinct outcomes because of social acceptance (Brohmann et al., 2007). Since social acceptance reflects stakeholder support or opposition, it can also influence the design of the renewable energy project and its integration into the cultural, environmental, social, and economic context of an area (Devine-Wright, 2007; Green, 1999). For successful implementation of renewable energy policies, social acceptance is increasingly recognized as an important ethical concern in technology implementation (Pellizzone et al., 2015).

3. Methodology

Official documents and reports related to geothermal energy development and campaign from private and public sectors such as local government (Municipality of Calauan, Bay and Santo Tomas), national government (Department of Energy), and non-government organizations were compiled and reviewed. Qualitative and quantitative data were both collected to have a deeper scope of the issue on social acceptance in the targeted site. The combination of methods was used to construct a comprehensive picture-perspective of the respondents through triangulation of data collected from the interview, survey, and focus group (Heras-Saizarbitoria et al., 2011).

In order to collect qualitative data, semi-structured interviews were conducted in April 2013 on different agencies and organizations related to geothermal energy campaign and development (Table 2). Key informants from the national government, academe, and NGOs were selected based on their involvement and engagement in renewable energy promotion and development. The objective of the interview of key informants was to analyze the overall structural framework of barriers and supporting factors in relation to the stages of geothermal energy development in the Philippines. To collect quantitative data, methodologies of social study such as social surveys were conducted on the residents of the local communities on November 2013. With the aim of gaining first-hand information, a semi-structured interview was utilized since it both allowed time for preparation of questions and allowed informants the freedom to express their views in their own terms which provided a deeper perspective of the topic at hand (Horton et al., 2004).

A social survey was also conducted in order to gain more insights into the perception of the local residents. The target respondents were the households from the seven out of the 11 barangays located within the Special Zone for Geothermal Development: Barangay Limao, Barangay Bitin, Barangay Santa Elena, Barangay San Vicente, Barangay San Pedro, Barangay San Felix, and Barangay San Jose. These seven barangays were selected on the grounds that they were the designated recipients of the revenue from national tax from the geothermal resource developers. A total of 268 households formed a representative sample from the seven barangays or about 35–40 persons in each barangay and their identities were undisclosed to preserve anonymity. The sample size considered the rules of social research and the requirements of statistics. The barangay workers referred the sites for sampling and the elements for sampling were randomly selected. A combination of snowball sampling and simple random sampling was determined suitable for survey data collection. Prior to conducting the social survey, research assistants were employed and oriented about the study area and social survey techniques. The research assistants briefed the respondents, distributed the questionnaire, and helped facilitate the

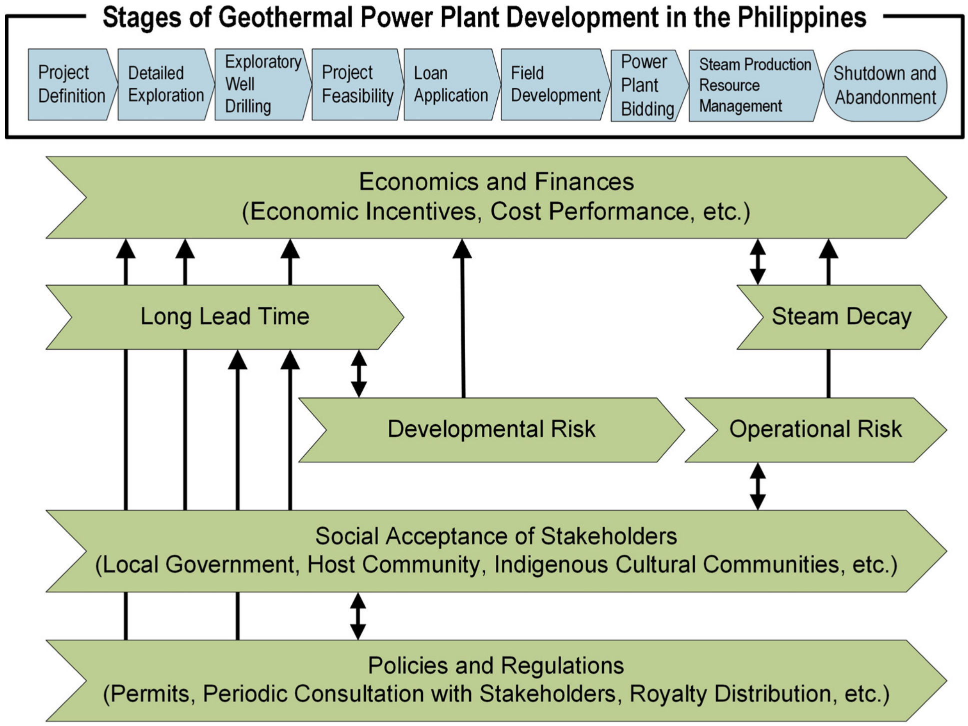

Fig. 2. Linkage map of barriers to introducing geothermal power plants in the Philippines modified from Dolor (2005) and Kubota et al. (2013).

filling up of the answer form.

The modified questionnaire for the social survey consists of five sections: (1) socio-demographics; (2) perceived knowledge; (3) perceived impacts; (4) perceived risks; and (5) social acceptance. The questionnaire contained simple multiple-choice questions using (a) closed questions with ordinal and nominal scale; and, (b) open questions (Geothermal Communities, 2013; Polyzou and Stamataki, 2010; Ratio, 2015).

The first section was about the basic socio-demographic details of the respondents, which was utilized in the statistical processing of the results. The second section, perceived knowledge about geothermal energy, covered questions about the respondent's knowledge on geothermal energy and the source of this knowledge. The third section, perceived impacts, incorporated the impacts of geothermal energy on the environment, economic activities, and the extent of this impact. The fourth section, perceived risks, comprised questions about natural disasters and risks, and their perceived association with geothermal activities. The fifth section, social acceptance, contained questions regarding support or opposition towards expansion, relocation and presence of geothermal facilities. In addition, questions about trust and interaction between the local communities and geothermal energy-related agencies and organizations were included in this section. The survey responses from respondents of the seven targeted barangays were later categorized into two clusters for comparison: (1) barangays with geothermal facilities and (2) barangays without geothermal facilities. The barangays with geothermal facilities are Barangays Bitin, Limao and Santa Elena while those without geothermal facilities are Barangays San Jose, San Vicente, San Felix, and San Pedro.

The data from the social survey were analyzed by two treatments: (1) classical statistical treatment; and, (2) the logistic regression analysis. Evaluation using the classical statistical treatment provided the main tendencies, without revealing any interrelations that may exist. Evaluation using the logistic regression was considered necessary since it provided quantitative results on the possible relations between the questions and the demographic details of the respondents. The logistic regression is a statistical model that is used to predict the outcome of a categorical dependent variable, e.g. existence or non-existence of a characteristic. This regression method measures the relationship between the dependent variable and one or more independent variables. These relationships can be expressed through probabilities or likelihood of occurrences. This is a useful method especially in cases where the prediction of the existence or non-existence of a characteristic is desirable (Howitt and Cramer, 2008; Peng et al., 2002; Polyzou and Stamataki, 2010). The analyses were performed using the logistic regression since the study considered dependent variables that were answerable by yes or no, or expressed as 0 or 1. The analytical models tried to look at the relationship of various independent variables, e.g. gender, educational attainment, on the dependent variable, e.g. respondents' perception of the effects of geothermal energy. The results of the logistical regression analysis are presented in Ratio (2015).

Focus group discussion was conducted on January 2015 among the members of the seven target barangays. The target participants were divided into two groups based on the presence of geothermal facilities in their respective area: (1) Barangays Limao, Bitin, and Santa Elena (vicinity with geothermal facilities); (2) Barangays San Jose, San Vicente, San Felix, and San Pedro (vicinity without geothermal facilities). The two sessions had a total of 28 participants from the residents and a few officials from the local government units and both discussions were conducted using similar topics and questions. Two sampling methods were employed in order to select participants for the focus group discussion. The snowball method was employed through referrals of barangays officials while the stratified sampling was employed with the local communities.

4. Results

4.1. Interview of key informants and focus group discussion

Semi-structured interviews among the different stakeholders of the Makiling-Banahaw Geothermal Complex were conducted in April 2013 (refer to Table 2). Considering the literature review and analysis of the stakeholder interview, a preliminary overall framework was created and patterned on the lifetime of geothermal power plants together with the important relationships related to factors inhibiting the adoption of geothermal energy (Fig. 2). While the policies have been laid out prior to the project development and exploration phase, social acceptance and project financing were both constant elements in the project life. The long lead time for the exploration phase had been a challenge which involved finances and bureaucratic processes such as securing permits and contracts with various government agencies and organizations. In order to operate the geothermal project economically, geothermal resource developers strategically balanced profits and sustainable steam exploitation against developmental risks and operational risks.

In the past, financial support through development agencies, such as World Bank, helped fund geothermal energy projects in the Philippines. Based on the results of the interview, the geothermal resource industry, represented by the National Geothermal Association of the Philippines (NGAP), was lobbying for additional economic incentives for constructing geothermal power plants because of huge capital investment and cost performance. In contrast, results of the focus group discussion indicated that local government units were lobbying with appropriate legislators for increased shares in the revenue from geothermal energy production from the national tax.

Results of the interview and focus group discussion reveal that the present legal framework for geothermal energy development should have clearer formulation and defined guidelines so local and foreign geothermal resource developers can comply without any delay. Prior to any renewable energy exploration activity, geothermal resource developers must comply with various Philippine laws and regulations implemented by various government agencies and groups: (a) Local Government Units; (b) Department of Environment and Natural Resources; (c) Department of Energy; and (e) National Commission on Indigenous Peoples. Complicated bureaucratic processes and overlapping functions of the government agencies, both local and national, together with the numerous processes, guidelines and requirements may pose as a challenge to geothermal resource development especially for foreign developers. Some areas for geothermal resource development encompass jurisdictions of different local government units, provincial government, and municipal government. According to NGAP, the lead-time for complex, long and sometimes unnecessary procedures to carry out exploration or well testing posed significant non-technical barriers to the timely execution of geothermal projects (Dumas, 2017; Ratio et al., 2019). In addition, politicking, such as disapproval of constituents towards geothermal energy projects, has been a widespread issue in these types of set-up which creates another obstacle for geothermal resource developers.

Results further reveal the concerns of the local communities in relation to the operation of the geothermal power plant, such as the diffusion of hydrogen sulfide and induced seismic activities. While some residents actively report these issues, some members of the local communities claimed that there were insufficient consultations from the side of the geothermal resource developers. This is interpreted as passive attitude towards the geothermal resource developers or interest groups. If geothermal resource developers were conducting any operation inside critical and protected areas and reserves, only few local residents take the initiative to report to the local government or interest groups. On the other hand, the Makiling-Banahaw Geothermal Complex developers face inherent risk in their operation because of the increasing population and economic activity in the area proximate to the facilities. Population increase also implies an increase in the number of illegal settlers and encroachment near steam pipelines in the geothermal complex.

Results also showed the dissatisfaction from the side of the local government especially with the regulations of the Renewable Energy Act of 2008, which outlines new energy policies and guidelines, particularly: (1) the percentage allocation of shares for the national and local governments; and (2) the changes in procedures and regulations regarding the remittance and claiming of shares (Ratio et al., 2019). The barangay, being the smallest unit of government, is often greatly affected by the distribution of share and socio-economic benefits in the proceeds from the development and utilization of the geothermal resource. The local government share allocation in the different barangays (hosting the geothermal resource) is determined primarily by the population of the barangay (70 %) and secondly by the land area (30 %). Even with the large land area of Barangays Bitin and Limao within the Special Zone for Geothermal Development, they receive less shares because of their small population.

The supporting factors include the compliance of geothermal developers, cooperation from local government, and stakeholders' interest in renewable energy. The quarterly meeting of the Multipartite Monitoring Team, which is composed of the community leaders, local residents, local government officials, technical experts from government agencies, and representatives from NGOs, has been esteemed as a venue to discuss variety of environmental issues and concerns over the steam field and power plant operations. These supporting factors foster harmony and develop integration between geothermal energy and the local communities.

Moreover, the national government and interest groups were currently bolstering renewable energy campaigns in the hope of spreading information on renewable energy and increasing public awareness. However ideal, it may only reach stakeholders near government facilities and not those in remotely encroached areas. Geothermal resource developers actively conduct their information campaigns through establishment of education facilities and centers for the stakeholders, particularly the local communities.

4.2. Results from the Social Survey

4.2.1. Socio-demographics

The household respondents were mostly female (62 %) while the male respondents only accounted for 38 %. The respondents were predominantly middle-aged, from 30 to 59 years old (62 %). Majority of the household respondents have an educational attainment level of high school and below (75 %). Public primary and secondary education (totaling to ten years at the time of the study) is free and compulsory. However, due to the socio-economic conditions in rural areas, many opt not to finish secondary education to help with the family livelihood. The sample has been overrepresented by female respondents because most male stakeholders during the data collection period were generally at work. Since sex as a socio-demographic factor has been considered as a variable for social acceptance, more male respondents would have been representative of the population.

In terms of the status of land ownership within the geothermal zone and location of residence in reference to facilities, a great number of respondents inherited the property (47 %), some purchased it (18 %), and few are on public land (10 %) (either on public housing facilities or as informal settlers). Almost half of the samples in-migrated (49 %) to the Makiling-Banahaw Geothermal Complex followed by those who were originally locals (46 %). Majority of the respondents in-migrated (72 %) after the construction of the geothermal facilities due to local economic development.

4.2.2. Perceived knowledge on and perceived impacts of geothermal energy

Regardless of the depth of knowledge about geothermal energy, the respondents conducted self-assessment of geothermal energy literacy. Eighty-three percent of the respondents considered themselves sufficiently knowledgeable about geothermal energy and the majority associate geothermal as thermal energy from the ground through steam. The majority are confident in their literacy about geothermal energy despite a generally low level of educational attainment. Eighty-nine percent of the respondents associated its use for electricity production over hot baths and greenhouse heating. Their top sources of information for these were personal encounter with the steam field and power plant infrastructures (22 %); schools (21 %); geothermal resource developers (19 %); and interaction with friends and family (15 %). Due to the low percentage, the other sources, including the government agencies, NGO and mass media (i.e. television and newspaper), were considered less effective sources of information. Residents' perceived knowledge about geothermal energy was found to be affected by these variables: presence of geothermal facilities; sex; educational attainment; and status of land ownership. Residents in barangays with geothermal facilities (Barangays Bitin, Limao and Santa Elena) were 2.8 times more likely to have knowledge of geothermal energy compared to those residents in barangays without geothermal facilities. Male stakeholders were 10.6 times more likely to have knowledge compared to female stakeholders because they are more engaged with current affairs through employment and community activities.

Respondents with college level education or better were 4.4 times more likely to have perceived knowledge of geothermal energy compared to those with high school level education only. On the other hand, residents on public land were less likely to have knowledge of geothermal energy compared to those residing on inherited land.

4.2.3. Perceived impacts on the environment

An overwhelming majority (83 %) of the respondents considered geothermal energy as having impacts on the environment through air pollution (i.e. odor) and noise pollution as the most significant environmental concerns. It was reported that Barangay Santa Elena is affected by hydrogen sulfide and sulfur dioxide emissions from the geothermal operations, which is causing nuisance and raising concerns on possible health effects (Municipality of Santo Tomas, 1997). Although non-detrimental to public health, it was considered a concern by key informants of the said barangay. Residents' perceived impacts of geothermal energy on the environment were only affected by one critical variable: presence of geothermal facilities. Residents of Barangays Bitin, Limao and Santa Elena were 2.2 times more likely to believe that geothermal energy affected the environment in comparison with those residents in barangays without geothermal facilities.

4.2.4. Risk perception

Majority of the respondents (both formal and informal settlers) considered their residences proximate to steam pipes (60 %) and to geothermal facilities (70 %). Majority of the respondents have seen first-hand well drilling operations (67 %). Since it was common for the majority of respondents to observe the steam pipes and geothermal facilities, respondents have long been in interaction with the existence of geothermal power operations.

Seven risks were considered in this study: earthquake, landslide, agricultural damage, subsidence, volcanic eruption, flood and forest destruction. The top two risks are earthquake and agricultural damages since these are observable experiences and phenomena for the local communities. Whether naturally occurring earthquakes or reinjection-induced microtremors, Barangays Bitin, Limao and Santa Elena "occasionally" experience them despite the absence of an active fault near the geothermal complex (Fig. 3). Unpublished seismicity data from 1915 to 2019 provided by the Philippine Institute of Volcanology and Seismology indicate very few shallow earthquakes occurring in the area with magnitudes not greater than 3. The representatives of the local communities who participated in the focus group discussion reiterated their concern for the delayed remuneration on the damages caused by induced microtremors on housing structures and by acid rain on crops and residential roofs.

The stakeholders' perception of the relationship between earthquake and geothermal energy were influenced by these variables: sex; status of land ownership; and knowledgeability on geothermal energy. Male stakeholders were less likely to think that earthquakes were associated with geothermal energy development and geothermal power operation. Residents on public land were less likely to think that earthquakes were associated with geothermal energy development and geothermal power operation than those residing on inherited land. Residents who have knowledge on geothermal energy were 2.6 times more likely to think that earthquakes were associated with geothermal energy activities.

Two variables affected the response pertaining to the association between landslide and geothermal energy: time of in-migration in relation to geothermal facility construction, and status of land ownership. Residents who in-migrated before the construction of geothermal facilities were less likely to associate landslide with geothermal energy activities. Those residing in purchased land were also less likely to think that landslide is associated with geothermal energy activities compared to those with inherited land.

Regarding the association between agricultural damage and geothermal energy, there was only one critical variable which was the presence of geothermal facilities in their own area. Residents of barangays with geothermal facilities (Bitin, Limao, and Santa Elena) were 1.8 times more likely to believe that agricultural damage is associated with geothermal energy. Anecdotes from informal interviews during the survey and results of focus group discussion revealed that agricultural damage was only attributed to acid rain due to gas emissions of geothermal operations.

On the other hand, four variables influenced the response referring to the association between subsidence and geothermal energy: presence of geothermal facilities; sex; status of land ownership; and, knowledgeability on geothermal energy. Residents of barangays with geothermal facilities (Bitin, Limao and Santa Elena) were 2.6 times more likely to believe that subsidence was associated with geothermal energy activities compared to the other four barangays.

Male stakeholders, compared to females, were 2.1 times more likely to think that subsidence was associated with geothermal energy. The most critical variable in this case was respondent's knowledgeability on geothermal energy. Stakeholders who are confident in their literacy on geothermal energy were 5.5 times more likely to associate subsidence with geothermal energy than stakeholders who deemed themselves deficient on geothermal literacy. Moreover, stakeholders on public land were less likely to think that subsidence was associated with geothermal energy compared to those with inherited land. Regarding the association between these three risks—volcanic eruption, flood and forest destruction—and geothermal energy development and power operation, none of the examined variables influenced the respondents' answer.

4.2.5. Social acceptance

Five agencies and organizations directly related to geothermal energy campaigns and promotions were identified in the study: (1) Department of Environment and Natural Resources (DENR); (2) Department of Energy (DOE); (3) geothermal resource developers (GRD); (4) Local Government Unit (LGU); and (5) non-government organizations (NGO). Overall, most respondents have had "seldom" interaction with GRD and LGU and "never" had any interaction with DENR, DOE and NGO. Despite the low frequency of interaction between the stakeholders, government agencies and NGOs related to geothermal energy promotion, the stakeholders "occasionally" trust these institutions (Fig. 4). While the geothermal resource developers continuously conduct information and education campaigns, they improve their relationship with local communities. Furthermore, the government agencies and NGOs also benefit from these campaigns through positive public image of geothermal energy, thereby soliciting trust.

As for the social acceptance towards the physical facilities of geothermal energy, the study identified three aspects: proximity, prospective expansion, and presence of geothermal energy facilities. For proximity of geothermal facilities, all the respondents of the seven barangays opposed its proximate locations in reference to their residences (Fig. 5). There were three variables that influenced the answers of residents: sex; educational attainment; and status of land ownership. Male stakeholders were twice more likely to allow relocation of geothermal facilities and steam pipes near their vicinity. Stakeholders with college level education were 3.8 times more likely to

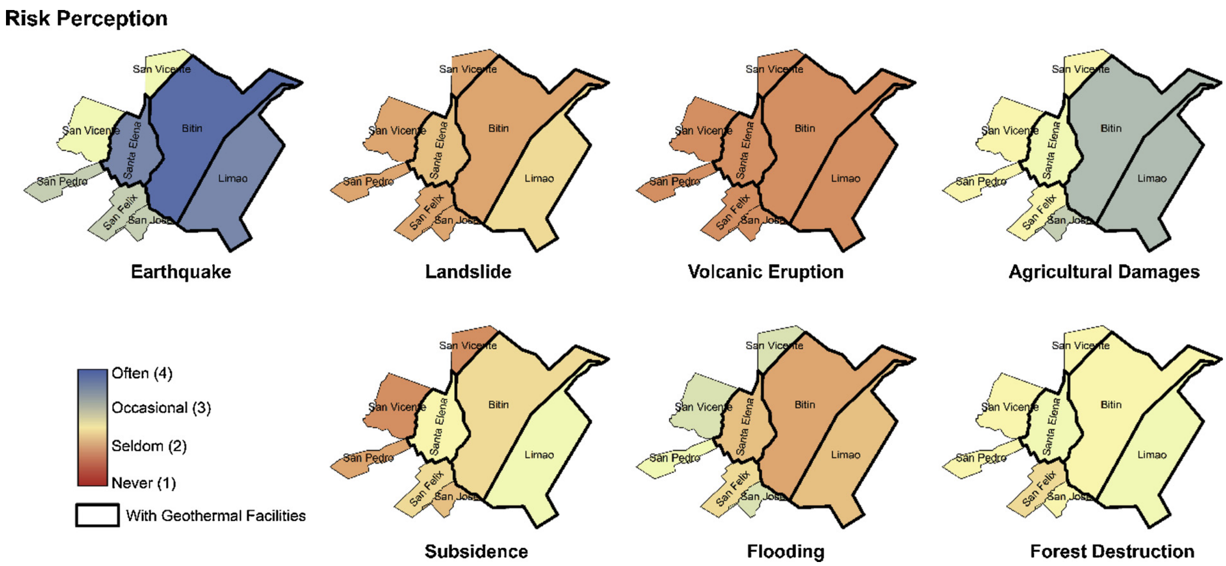

Fig. 3. Seven risks were considered for the stakeholders' perception.

allow relocation as well. In addition, stakeholders in public land who exhibit weak place attachment are four times more likely to allow relocation near their areacompared to those with inherited land.

In terms of prospective expansion of geothermal facilities, majority of the respondents from all the seven barangays did not support further expansion (Fig. 5). The critical variables that influenced the responses were: presence of geothermal facilities; sex; education; and status of land ownership. Stakeholders of barangays with geothermal facilities (Bitin, Limao and Santa Elena) were 1.8 times more likely to allow the expansion of geothermal facilities within the vicinity compared to the other four barangays, thereby revealing integration of geothermal energy and local communities as manifested by adequate social acceptance. Male stakeholders were 2.7 times more likely to allow expansion compared to female stakeholders. Respondents with higher education were 2.4 times more likely to allow expansion as well. More significantly, residents in public land were 2.9 times more likely to allow expansion compared to those with inherited land.

As for the social acceptance on the presence of geothermal facilities, majority of the respondents from the three barangays: Bitin, Limao and Santa Elena were supportive of its presence (Fig. 5). Although these three barangays hosted most of the geothermal energy facilities and were prone to experience nuisance from noise and odor, they still supported the development of geothermal energy in their vicinity. There were several critical variables that influenced the response: presence of geothermal facilities; sex; educational attainment; and status of land ownership. Stakeholders from Barangays Bitin, Limao and Santa Elena were 1.6 times more likely to support the presence of geothermal facilities compared to the other four barangays which reveals harmony between technology and local communities. Male stakeholders were 1.05 times more likely to support geothermal facilities compared to female stakeholders. On the contrary, stakeholders with college-level education were less likely to support the presence of geothermal facilities because they fully understand all impacts of this development and how it threatens their place-attachment.

5. Discussion

The geothermal resource developer has been tolerant towards informal settlers to safeguard harmony in the community although they have been warned of the risks in the area. The local communities have been appreciative of this harmony and the tangible benefits of the geothermal resource developers through medical and dental missions

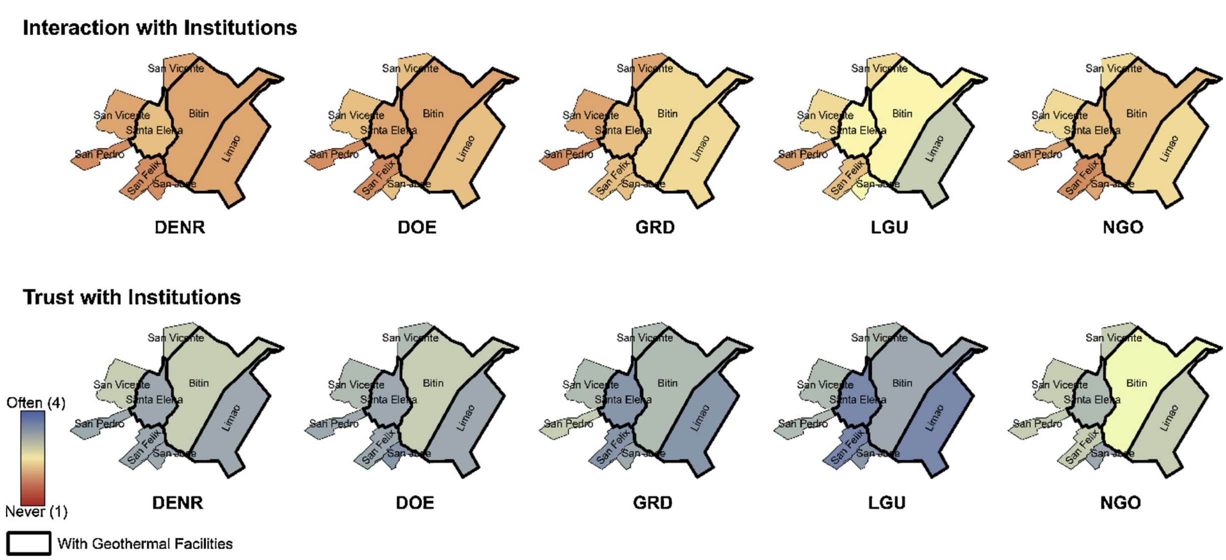

Fig. 4. Frequency of interaction with institutions promoting geothermal energy and the level of trust toward them.

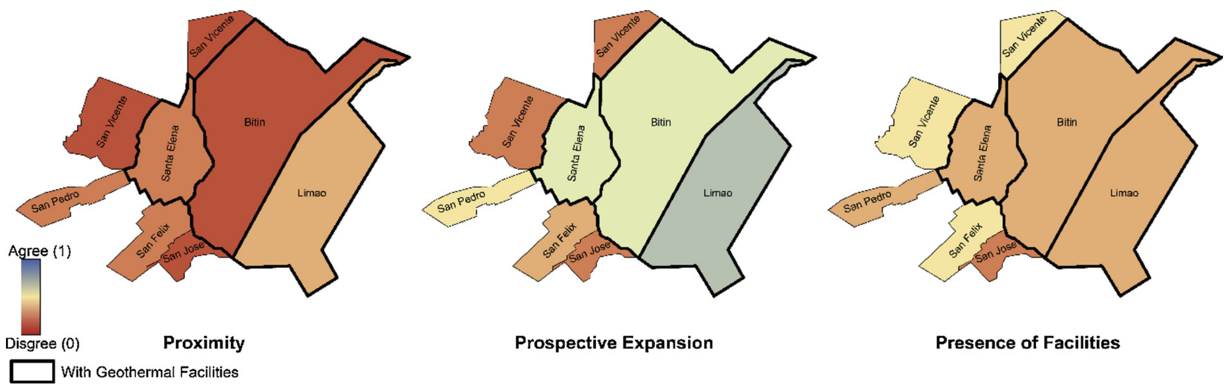

Fig. 5. The social acceptability on the proximity, prospective expansion and presence of geothermal energy facilities within the Geothermal Development Zone.

and scholarship opportunities among others which motivated most stakeholders to support the geothermal energy development in the area.

Aimed at increasing the share of renewable energy sources in the country's energy mix, the Renewable Energy Act of 2008 provided economic incentives for renewable energy investments but created tradeoffs on the side of the stakeholders particularly to the local government within the geothermal vicinity, which caused dissatisfaction in terms of the distribution and remittance of shares from national wealth. As for the local government, the concern on the delayed remittance of share from the national wealth may have caused distrust with the national government and geothermal resource developers.

While the Multipartite Monitoring Team has been represented by local stakeholders from the community and academe and served as the channel for complaints and grievances concerning the geothermal energy activities, some local residents opted to report their complaints to interest groups whom they trust more. The local residents' trust (or lack of it) towards the Multipartite Monitoring Team has an impact on their support towards the operations of the geothermal resource developers. The complex dynamics of trust/distrust among the local residents, interest groups, geothermal resource developers and local government have an effect on their social acceptance particularly regarding possible project expansion and proximity to residences. Trust among these stakeholders could be improved by engaging more local residents to actively participate in the public consultation and transparent reporting on the part of geothermal resource developers. Stakeholder engagement fostered by trust creates opportunities for integration between geothermal energy and the local communities.

Almost all respondents were only familiar with the use of geothermal energy for power production, as compared to other direct uses such as agricultural drying and balneology. Residents from Barangays Bitin, Limao and Santa Elena (barangays hosting the geothermal facilities) can be characterized as having basic knowledge on geothermal energy and having the belief that geothermal energy has effects on the environment. There were three factors strongly linked with residents' perception of knowledge about geothermal energy technology: male sex, their proximity to power plant, and college-level education. While majority of the stakeholders are confident of their knowledge of geothermal energy, the local communities with proximate geothermal facilities (particularly, Barangays Santa Elena, Limao and Bitin) are more sufficiently literate on geothermal energy and environmental impact compared to the others. The presence of these facilities is integrated in their place identity. Moreover, majority of the stakeholders privately own their residential and/or agricultural land, hence, property ownership further develops place attachment. However, the informal settlers have remained detached to the surrounding facilities. As reported by Ansolabehere and Konisky (2009) that sex, as a sociodemographic factor, is linked with social acceptance of power plants, this case study shows that male stakeholders residing proximate to geothermal plants are more likely confident on their literacy about geothermal technology since they have visuals on the pipes and other power plant facilities.

The main source of knowledge on geothermal energy for the respondents was people's interaction rather than mass media (i.e. radio, television, newspaper among others) and relevant agencies (government and NGO). The contribution of mass media, government, and non-government agencies on this subject matter was not as high which meant that the frequency or impact of information campaigns or activities through mass media has been less effective. In this case, peoples' perception of risk and benefits of the geothermal energy technology was strongly influenced by fellow residents' opinions rather than by mass media.

Air pollution and noise pollution were the top environmental concerns identified by the respondents and these were also reported in different public documents from Municipal Comprehensive Land Use Plan since these were easily observable environmental issues. Despite the efforts of geothermal resource developers to minimize their operations' impact on the environment, the presence of power plant structures leaves an impression to the residents that it will always have an environmental footprint.

Male stakeholders and those living in public spaces were less likely to associate earthquakes with geothermal energy. These informal settlers lack access to education and other social services, hence, insufficient knowledge on geothermal energy technology may simply have a great effect on their opinion on this matter. Stakeholders who are confident on their literacy on geothermal energy strongly associate earthquake with geothermal energy. The induced seismicity is a primary concern and main nuisance for the stakeholders, rather than risk for property damage.

Although landslides in the vicinity has not been a major concern for the community, respondents who were already living there before the construction of geothermal facilities more than 30 years ago were less likely to associate landslide with geothermal energy activities. Being a low-land agricultural area, it was not really prone to landslide even before the land was converted for the use of geothermal power plant. These respondents have a historical knowledge of how the area was prior to the development of the geothermal plant which strongly supported this opinion. In addition, those respondents who have purchased land in the vicinity had a strong belief in the absence of landslide hazards which added confidence in their decision to reside in the vicinity despite the proximity to geothermal energy facilities and structures.

The respondents associated agricultural damage to geothermal energy operations regardless whether it was a direct or indirect result of the operations. The respondents have reported damages of acid rain in their own house roofs which can also equally cause damage to their agricultural crops. Most of the stakeholders who have experienced this have been residing proximate to the geothermal facilities. The delayed remuneration for the damages has been a big issue for them.

Although subsidence, as an impact of geothermal energy technology, has been a concern for the respondents, there were three factors that have been identified to have supported their opinion on the connection of subsidence with geothermal energy activities: proximity of residence to facilities, male sex, and knowledgeability on geothermal energy. As previously presented in the results, the male respondents believed in their personal knowledge about geothermal energy, and since geothermal energy utilizes geothermal fluids and steam from the ground, respondents believed the use of these steam and fluid can alter the ground regardless if they have complete scientific understanding of it or not.

Opposition to the proximity of the geothermal energy facilities may be due to the cited impacts of geothermal power operations on the community. The low support of the majority of respondents for prospective expansion of geothermal facilities was due to the opinion that more steam pipes would increase occurrence of noise from the wellheads despite mitigations by installation of silencers. The main reason for the respondents' low support on these cases were because of the nuisances of the odor and noise and their opinion that these are health risks.

As for the overall presence of the geothermal energy facilities in the area, the stakeholders in Barangays Bitin, Limao and Santa Elena, which have facilities and infrastructures, expressed their social acceptance. These stakeholders have integrated with geothermal energy (including its negative impacts and environmental benefits). Through the efforts of various stakeholders, the local communities and geothermal energy have prospered in harmonious coexistence. In contrast, the other four barangays were non-supportive of the presence of the geothermal facilities. They may still be considering the geothermal facilities as disruption to place attachment.

6. Conclusion

The results of this case study which identified and analyzed the significant issues among the stakeholders and supporting factors for the Makiling-Banahaw geothermal project will provide important guidelines for stakeholder engagement. In the case of the Makiling-Banahaw Geothermal Complex, its operation for more than 30 years could be attributed to the harmonious integration of technology and various stakeholders from the local government, local communities, and geothermal resource developers. Several factors, such as political support in terms of policies and regulations, contributed to this despite the dissatisfaction of the Barangay officials on the regulations relating to share allocations of the national wealth. Economic support through past loans from different funding agencies, such as the World Bank, made it possible for the project to progress. The Makiling-Banahaw Geothermal Project has had a peaceful relationship with its local communities compared to other projects (e.g. the Mindanao Geothermal Project which is co-located in sensitive areas: a national park, an ASEAN heritage area, and ancestral domain of indigenous cultural communities/indigenous people) (Ratio et al., 2019).

The assessment of the overall results of the case study indicates that residents from the barangays with geothermal facilities (Barangays Bitin, Limao and Santa Elena) were more agreeable to geothermal energy compared with those from the other barangays farther from the geothermal facilities (Barangays San Felix, San Jose, San Pedro and San Vicente). Among the local residents, geothermal energy supporters tend to be male stakeholders, those who reside in barangays with geothermal facilities, and those living on public land. While there were limited interactions between the local residents and geothermal energy developers, they still trusted the geothermal resource developers and local government but their trust may be fragile. The geothermal energy promoters, such as the geothermal resource developers and NGOs, should engage the local communities. Stakeholder dialogues and focus group discussions, rather than mass media, are more effective tools to increase technology literacy and develop trust among the various stakeholders. Strengthening the trust among the stakeholders—local communities, local government, and geothermal resource developers—can improve relationship, thus affect opinions towards renewable energy technologies and reinforce public support. While air and noise pollution are primary environmental concerns, earthquakes, as induced microtremors, and agricultural damages are the principal risks experienced by the local communities, particularly those proximate to the facilities. In order to deepen the trust of local residents with other stakeholders, more frequent periodic and strategic engagement initiated by geothermal resource developers with the support of local government can assure that the local communities' interest and welfare are carefully considered. While the Multipartite Monitoring Team (MMT) has been an effective tool for stakeholder representation, their main role is to monitor the environmental effects of geothermal activities and validate results. The MMT is not mandated by law to conduct information and education campaign unless recommended by the government (i.e. the Environmental Management Bureau, Department of Environment and Natural Resources) (Ratio et al., 2019). Transparent communication policy on the side of geothermal resource developers, such as sharing solid data about the environmental impacts of the operations, through quarterly information campaigns can assure the local communities of the stability and safety of their operations. Launching and maintaining a dialogue among all relevant stakeholders that takes into account the views of the local communities are the way forward to ensure social acceptance in the future.

Moreover, the findings and conclusions of the case study can be biased and site-specific due to the characteristics of the geothermal area. Since the Makiling-Banahaw Geothermal Complex is not located on a high-altitude mountainous national park and does not involve any indigenous people, it is recommended to study other existing geothermal projects that are involved in national park regulation conflicts or sites which house indigenous people to characterize and compare other geothermal energy areas. Because of limited published studies related to social acceptability of geothermal energy in the Philippines, the recommendations are to conduct a study quantifying the level of public engagement at different times since the geothermal development started and to assess the social acceptability of existing and new geothermal plants.

Declaration of Competing Interest

None.

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