CITIZEN SCIENCE:
THEORY AND PRACTICE

From a Seismological Network to a Socio-Seismological One: A Citizen Science Experiment in Haïti to Reduce Seismic Risk: Analysis of a "Small Box" that Can Do a Lot

RESEARCH PAPER

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ABSTRACT

On January 12, 2010, Haiti was hit by one of the largest seismic disasters known to date. At the time, the culture and perception of seismic risk was low among the population and—because of the lack of seismic sensors in Haiti—so was seismological knowledge.

In a citizen seismology approach, the S2RHAI project used low-cost seismic sensors (Raspberry Shake) to (1) complement the national seismic network and (2) to improve risk perception, preparedness, and scientific knowledge of the population. Through these objectives, we introduce a paradigm shift in which seismic networks are not only composed of sensors, but also of citizens who gather around these tools and the information they produce.

We present here the results of a qualitative survey of 15 Raspberry Shake (RS) seismometer hosts in Haiti. Semi-structured interviews were conducted to learn about users' experience to assess their motivations, difficulties, and expectations in this citizen seismology process. We found that RS hosts expressed pride and interest in being part of the RS network and actively contributing to risk reduction in their community. Some of them reported a form of empowerment in that they could compensate for the deficiency of the state, which they generally distrust. However, the RS hosts also expressed the need for more technical and scientific support from scientists. Also, few of them engaged in mediation activities or discussions with their community members, partly because they feared that this would awaken the trauma caused by the earthquake of 12 January, 2010. This allowed us to list concrete actions to (1) improve the seismic information system, (2) better integrate the volunteers into the network, (3) enrich the collaboration between citizens and seismologists, and (4) accompany them in their role as ambassadors to their community. We conclude that understanding the motivations, obstacles, and expectations of volunteers is essential to increase the chances of sustainability of this citizen seismology project.

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INTRODUCTION

Haiti shares the island of Hispaniola with the Dominican Republic, at the boundary between the Caribbean and North American tectonic plates (Figure 1). The island is crossed by seismically active geological faults, which regularly cause major earthquakes (Scherer 1912). On January 12, 2010, an event of magnitude 7.0 devastated the metropolitan area of Port-au-Prince, the country's capital city, as well as the communes of Carrefour and Léogane to the west, and Jacmel further south. It caused the deaths of tens of thousands of people and injured hundreds of thousands more (Schwartz, Pierre, and Calpas 2011). The trauma for all those who witnessed the disaster and lived through the terrible following hours, was real and tremendous (Cénat et al. 2017). Many had to move to one of the refugee camps that swarmed the territory. Ten years later, despite the massive presence of numerous aid mechanisms, notably under the aegis of the United Nations (UN) and many nongovernmental organizations (national and international NGOs), traces of the earthquake can still be seen in the landscape. Haiti has not recovered from the 100% GDP loss caused by the earthquake (Haiti Earthquake PDNA 2010). To the contrary, economic, political, and security instability have increased since. In 2012, 58% of the population was living below the poverty line (World Bank 2019) while the country was sinking into a serious socioeconomic crisis marked by scandals (such as that of the PetroCaribe funds) and violence. The president of the republic was even assassinated in his official residence in July 2021, and gangs control access to oil terminals, bringing the country to its knees.

The major disaster of 2010 highlighted a lack of preparedness to face earthquakes in Haiti, on the parts of citizens and scientists alike (Calais 2019). Indeed, seismic risk culture and perception were very low among the population, governance bodies, and their international partners. Moreover, knowledge of local seismicity was also very limited, especially because of the absence of seismic sensors on the national territory, which made seismologists almost blind as to the capacity of geological faults to generate major earthquakes, even though many of those faults were known.

Such a situation is well known to seismologists in developing countries who often face obstacles that are both institutional and scientific (e.g., Bent et al. 2018; Subedi et al. 2020). Indeed, relying on institutions in these contexts has its limits for financial reasons (the State and its donors have limited resources that go primarily to short-term objectives such as food security, poverty, governance, etc.), for continuity issues (the turnover in personnel within institutions is very rapid, there is little to no planning, little or no long-term vision, etc.), and for political reasons (for the electoral candidates, the earthquake is not considered to bring back votes, protecting oneself is expensive, etc.). But relying only on the scientific community also has its limits, again for financial reasons (maintaining the networks generates significant costs), technical capacity (there are very few trained seismologists in Haiti, for instance), because the scientific discourse is poorly adapted to public expectations, and because of a lack of interest in earthquakes and the associated risks from national and international institutions, especially at times when climate change has taken center stage. However, faced

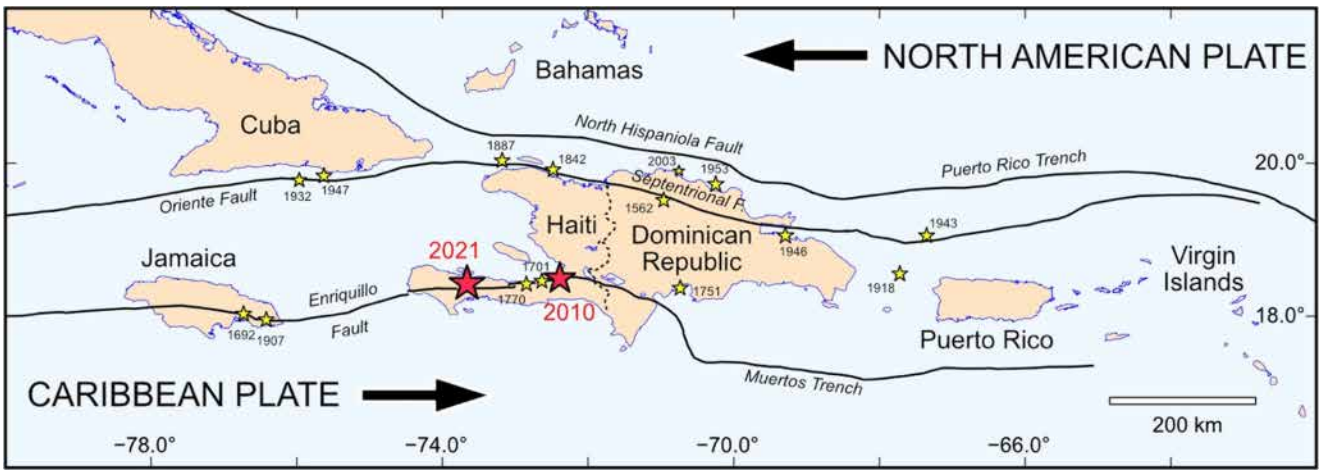

Figure 1 Location map. Haiti and the Dominican Republic share the island of Hispaniola. The black lines indicate the major seismic faults, which accommodate the movement between the North American (north) and Caribbean (south) plates whose relative displacement (2 cm/year) is shown by the black arrows. The most important historical earthquakes in terms of damage are indicated by yellow stars. The red stars indicate the epicenters of the earthquakes of January 12, 2010 and August 14, 2021.

with these difficulties, it remains essential to strengthen seismological networks to collect more scientific data, but also to use social networks to make that information available and effective to the population with the aim of raising awareness and reducing seismic risk. As a whole, the issue is to design a model that will make such a system operational, appropriated by all, and sustainable; and to do all of this with limited State resources or capacities—while strengthening local capacities—and with the help of social networks.

In this context, a multidisciplinary research team combining seismology and social sciences has been deployed in Haiti between 2019 and 2021 within a project named S2RHAI. The aim of S2RHAI was to test the feasibility of an approach in which seismic observations are carried out by distributing small (10 × 10 × 5 cm), low-cost and low-maintenance Raspberry Shake (RS) seismometers (Figure 2) to non-scientific volunteers throughout the country: 7 Haitians and 3 foreigners.

Volunteers' recruitment criteria are more detailed in the Appendix 1 on methodology, but included 1) internet and electricity access and 2) homogeneous geographical distribution for earthquake location purposes. Figure 3 shows a map of the RS station hosts: Several are located in the Port-au-Prince area; others are in Jacmel, in Anse-à-Veau, in Saint Louis du Sud, and in Jérémie, which are not far from the Presqu'Ile du Sud fault,and other RS stations are in Môle St Nicolas and in Cap Haïtien, which are not far from the Septentrional fault.

Figure 2 Photo of a Raspberry Shake (RS) seismometer installed at a host located in Port-au-Prince. The RS is lying on the floor in a corner of their living room, behind a piece of furniture that hosts a TV and various electronics. The mobile phone gives the scale. The connection to the electricity (black cable) and the internet router (blue cable) can be seen.

The results of the data produced by the RS are accessible via a website (https://ayiti.unice.fr/sismo-ayiti/), which is equipped with an automatic earthquake detection system. Automatic detections are then verified and validated by a seismologist. In order to facilitate communication and information sharing, a WhatsApp group has been created with RS hosts and scientists.

Two years after the installation of these RS stations, we can now question the impact of their presence on the hosts. Have they increased the hosts' awareness and knowledge of risk? To what extent do the hosts feel integrated in this new socio-seismological network? Did the RS have an impact on the hosts' community? Are hosts on their way to becoming «ambassadors,» spreading earthquake knowledge more widely around them? Finally, our research reflects on doing citizen science in places where the government is unable or unwilling to monitor environmental threats.

Although citizen science is growing, there are not many citizen seismology projects based on low-cost stations (in California, see Cochran et al. 2009; Clayton et al. 2011), and they are usually distributed only in a specific place, like in schools (Subedi et al. 2020), and not to a large sample of different citizens. Our approach increases the reflection on this method and its social significance, especially in a country where access to science and knowledge is complicated (low level of education, deficient state, very disturbed economic context, etc.). Our particular interest is in the fact that seismometers were installed to obtain seismological information as much as to understand the populations that host or live around these tools. The dialogue with the hosts is the basis of the investigation, not an outcome. It seeks to see if it is possible, and under what conditions, for the hosting citizen to be proactively involved beyond just accepting that a seismologist put a device in his home, thus promoting and measuring citizen involvement. We can then speak of co-construction of the project, and of the evolution of the project along with them, as has been imagined several times by researchers and adapted according to projects and research fields (Hernández et al. 2022). Our whole team was keenly aware of the social construction of the research and also of the social analysis of its functioning and of the results (Calais et al. 2020).

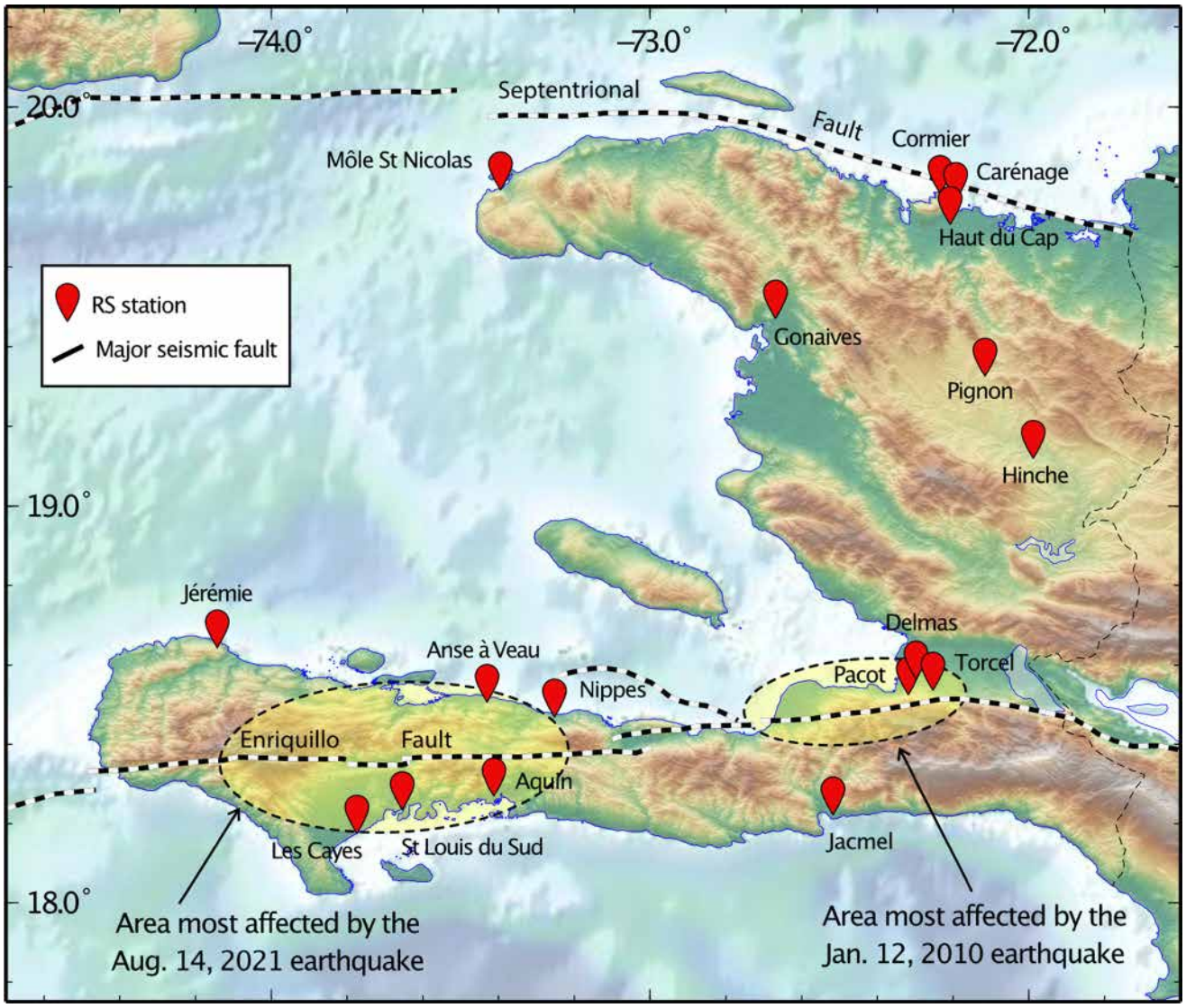

Figure 3 Map of the location of Raspberry Shake stations in Haiti at the time of the interviews (*red*) and subsequently installed (*yellow*), as of October 24, 2021. Regions affected by the 2010 and 2021 earthquakes are indicated approximately by yellow ellipses.

METHODOLOGY

To address these questions, we conducted semi-structured interviews with 10 hosts in order to learn from their experience and to assess their motivations, difficulties, and expectations (see Appendix 1). The interview consisted of about 40 questions, which were organized around four themes. The first questions asked about the host's profile: who they were, their past experiences, and their previous knowledge of seismology. The second section looked at their experience with the RS they had been hosting: how and why they hosted one and their interest in the device, from maintenance to data collection, including accessing their RS information or the project website. The third part asked about the community dimension of this participation: Were the RSs introduced to visitors or family, for example, or could a sense of belonging to a "scientific community" be identified? Finally, the fourth part was an open space for comments and suggestions from the hosts, with the goal of finding concrete ways of improving their experience.

These interviews, made by phone then transcribed, were analyzed by researchers from different disciplines in order to identify the salient elements we present here. Because of the small number of interviews, the coding method was inadequate. We adopted a very qualitative method revealing people's explicit and implicit discourses by sharing and discussing all transcripts. The cross-disciplinary perspectives of the team's researchers led to a consensus on the major themes expressed by the interviewees.

In this paper, we note the enthusiasm of the hosts and their motivation to host the RSs and to continue with the project. The article will conclude with a discussion of the

future of the project, as shaped by this citizen science experience. It shows how the participatory aspect of our approach is really motivating, individually and collectively, especially in the specific context of Haiti, between failed-state and magical world.

A STRONG ENTHUSIASM FOR PARTICIPATING IN A COLLECTIVE CITIZEN SCIENCE PROJECT

CONTRIBUTING IN THE LONG TERM AND THROUGH SCIENCE, TO THE DEVELOPMENT OF THEIR COUNTRY

Research on citizen science shows that its success relies heavily on the motivation of participants (Nov et al. 2011) and on a project's ability to support participants' information needs (Bossu et al. 2018). The interviews reveal that the enthusiasm for participating in the S2RHAI project is fueled by a strong desire to help "develop" the country. The idea conveyed by the hosts is that science and the data it produces can help Haiti advance and ensure its sustainable development. All the hosts still have the traumatic earthquake of 2010 in mind, and they understand the importance of limiting the risk in order to avoid another disaster. The seismic data collected by the RSs are therefore not only perceived in their purely scientific dimension, but also in their practical, risk-management dimension. The data produced by the RSs are considered valuable information to be taken care of and archived. For example, a host in Pignon told us: "*I know that everyone needs data but that it is extremely difficult to access and collect it in Haiti. So, when I heard about the RS… and since I have a home with electricity and internet, I offered to host one […] Having the knowledge available is important. For me it helps the world.*"[1]

This risk management for the development of the country includes three main aspects. Firstly, the hosts hope that this RS-based system will make it possible to improve awareness of the risk, to know that it is present, to measure it, and perhaps even to control it. Awareness and knowledge of the risk appear to be *sine qua non* conditions to allow the future to be envisaged, even if it is initially painful. "*I understood from Eric*[2] *the more of these devices there are, especially in the most remote areas, the more we will be able to detect and record these seismic movements with precision. So that's what it's all about. […] I think that's what we, Haitians, need to do it right now so that it can, how should I say, move forward. So that it can progress.*" (Host in Jérémie).

They also hope that this will lead to better construction practices, to make buildings stronger and therefore more durable, as one host in Jérémie said: "*And then, based on what we have understood or based on the movements of the ground, based on the orientation of these movements, we could deduce other construction techniques. And then ask the municipalities to impose these conditions on the builders.*" While it was not present specifically in the questionnaire, the mention of construction in the interviews is frequent, and as one hostess in Jacmel points out, is linked to the trauma of 2010: "*We have to be more careful, for example, in construction. For example, I take that into account in construction because I was traumatized enough as it is.*" She goes on to explain that, as an investor, she understands the need to document risks to be able to lay out scenarios for them and, in fine, to better control for them.

Finally, some hosts also hope that the data collected by the RSs will eventually make it possible to predict earthquakes, or at least to issue an early warning to the population, and thus reduce the risk. In this respect, the words of a hostess in Pacot are particularly revealing of this desire for prediction: "*All the people in Haiti want is to have advance notice of an earthquake. If it's not possible according to Prépetit*[3] *to get an advance notice of an earthquake, for me it's still the beginning of an advance notice mechanism. Which you couldn't do at the moment. […] If with the Raspberry Shake and the network we can follow the general trends, maybe we can see in advance big earthquakes, small earthquakes in an area that concerns me.*" Indeed, if earthquake prediction is not scientifically feasible today, it is possible—under certain conditions and thanks to precise detection devices and a highly reliable communication system—to detect an earthquake in its early phase and warn populations further away from the epicenter a few seconds before they feel the shaking (Allen R. 2019; Bossu et al. 2021). This so-called "earthquake early warning" service is operational in Japan, Mexico, and California for instance. It requires technological means that are however far from being available in Haiti. This desire to predict earthquakes is also accompanied by the hope of being able to prevent tsunamis, as pointed out by a host in Anse-à-Veau: "*This is information [data on an earthquake] that comes after the fact. […] We expect it [the RS] to facilitate responsiveness. The town of Anse-à-Veau is located in a coastal area, and if there is a real concern, it is with regard to underwater earthquakes. In case of a tsunami for example, the device could allow the evacuation of the population between the first tremors felt and the first waves. Its usefulness is not to be demonstrated. It is even essential.*" In any case, in order for the project to really help the development of the country, many volunteers stress the need for it to be sustainable. A host at Môle Saint Nicolas, for example, expresses his desire for the project to last and "*for all generations to be touched by the issue.*"

A COLLECTIVE INTEREST THAT TAKES PRECEDENCE OVER INDIVIDUAL INTEREST

Citizen science takes on its full meaning here. We can indeed assume that all these reasons for participating in the project, and the satisfaction expressed in the exercise, strengthen the inclusion of citizens. The participants not only make up for the lack of involvement of the State, but they participate both as individuals and as part of a national community serving their country and their future. However, in general in Haiti, historical, socio-cultural, economic, and political factors make individualism very strong. A person's network of relatives is a bonus, in a large part because it is through them that one survives on a daily basis: It provides an environment of mutual aid, particularly in the face of the shortcomings of the State, helping with the purchase of products, with loans between families, with childcare, etc. (Corbet 2012). The S2RHAI network, which connects citizens scattered throughout the country, conversely allows for the existence of a larger community by including them in a scientific endeavor as citizens and orienting them toward a common goal.

This investment in the project, which takes on a collective, even political, color, reveals in both overt and covert ways a real pride in project participation. "*I am very happy to host the system because it is the only one in the area. At least when there is something going on, it allows us to know what is going on. [...] For me it was a citizen's duty and I thought it was perfectly normal to do so*," said a hostess in Jacmel, for example.

As can be read in the original quotes (see Appendix 2 with quotes and translations), this pride is expressed recurrently; some affirm the pleasure they experience from participating in an innovative project, some appreciate being considered a local authority figure through the possession of a seismometer, and others express a sense of honor in working for science in general and the country in particular. It is one of the most positive elements of the project: One could indeed have thought that people would lose interest or would disinvest, or at the very least that they would not express specific feelings about their cooperation. Especially since there was no strong earthquake, and a fortiori no destructive earthquake, between the installation of the RSs and our survey, their "watch" could have seemed of little use. Overall, by seizing scientific data to address the failures of the state and to take control of their future and that of the community, the volunteers demonstrate a form of empowerment common to many citizen science projects (Bonney et al. 2016; Kinchy 2017). Individuals seize the opportunity to fully exercise their power as citizens through concrete action and for the collective good. And as one host in Anse-à-Veau rightly notes, "information is power": As for seismology, it does not (yet) have the power to predict an earthquake. But, for citizens, it is the power to participate and to be included in something bigger than any single individual's capacity.

MAKING UP FOR THE FAILURE OF THE STATE

Although this was not formulated explicitly, a certain distrust of the State is apparent from the interviews. This is recurrent in Haiti, where the State does not ensure its regalian prerogatives such as security, education, infrastructure, etc. (Wargny 2008). The Haitian state has put in place some disaster risk–management mechanisms (cyclones, floods, earthquakes) thanks to support from the international community, and certain local figures, such as engineer Claude Prépetit, the current Director General of the Bureau des Mines et de l'Energie (BME), have made their mark in this landscape. But this is quite recent and, so far, occurs with little participation from the local population, who therefore remain spectators and, above all, under-informed. This lack of inclusion of citizens in Haiti in the various institutional arrangements is characteristic and has already been investigated in numerous studies (Lundhal 1983; Trouillot 1990; Trouillot 2003). Hosting an RS and providing useful information therefore embodies real citizen involvement for the hosts and helps to overcome the failings of the State, which has not been able to set up an operational seismological network, for instance. RS host volunteers are therefore no longer just beneficiaries of science, but full-fledged actors who help produce knowledge about Haiti, in Haiti.

In this scientific approach, the national dimension, despite the absence of the State, is important. The S2RHAI team is composed of Haitian and French scientists, many of whom were in contact with the hosts when they were "recruited" or when the RS was set up at their place. We can assume that the actual involvement of local researchers reinforces the fact that this is a project that does not just come from the outside, but is part of a dynamic of collaboration and co-construction with Haitians.

However, the presence of French researchers in the team can be perceived from different, sometimes contradictory angles. For example, it may suggest that Haitian researchers cannot support this scientific project alone (in terms of skills and technical and financial resources). It could even be interpreted as a form of "scientific interference," a recurring theme in local populist discourse, which in particular criticizes the foreign policy of the great powers vis-à-vis Haiti as well as the omnipresence of international NGOs in the country (Katz 2014; Schuller 2016). Haiti is indeed characterized by a very strong foreign presence, in particular via a large number of solidarity projects through NGOs, some of them established in the country for a long time and with no intention to leave. However, even though

many of them were designed to fulfill the needs of Haitians, relatively little was done with or by the Haitians. That said, the presence of foreign researchers can also be perceived as positive, as the image of the international, renowned researcher also carries some cachet, and the hosts were enthusiastic about participating in a project of international scope. Our future surveys will clarify RS hosts' perception of the research team composition.

A STILL-INCOMPLETE INTEGRATION INTO THE NETWORK

Much more than a sense of usefulness to country, the comments of the hosts reflect a sense of belonging to the seismic network, of legitimacy, and of commitment under various forms. While some claim to have acquired knowledge about seismology, others point to the limitations of this effort and refer to scientists as the "holders of knowledge," while at the same time placing themselves outside of the community we are trying to build. The words of a host at Môle Saint Nicolas is emblematic of this attenuation of his own knowledge: "*I am used to watching [on the website] those [earthquakes] that occur in the Dominican Republic as well. […] I see these things but I don't record more. You know, my knowledge is limited in this area.*"

This variable belonging to the seismic citizen network can also be observed in the interlocutors chosen during the exchanges. If, when an earthquake is felt, hosts can compare amongst them what they felt or measured, the vast majority of requests on the WhatsApp group mentioned above are directed towards the "knowledgeable," that is, the scientists. We thus note a limit in our attempt to reduce the asymmetry of the power/knowledge duo, which should encourages us to better reflect on the social meaning of our research (Bojovic et al. 2021). The voice of the latter is authoritative, closes a debate on the magnitude of an earthquake, or even silences rumors about hypothetical earthquakes in a given region. For example, on July 23, 2021, a rumor of an earthquake that had caused significant damage, with a photo to back it up, spread through the WhatsApp group. It was important to find out whether this was true. Even if there are other ways to disprove the news, the answers of the scientists and their "proofs" (notably by referring to the project website) sounded the end of the discussion; it was not an earthquake but the sad and natural failing of an aged ceiling in a high school. The public view of scientific authority is reflected both in the direction of the questions (toward scientists) and in the acceptance of the responses of the "knowers." However, in the S2RHAI project and in the interviews, the figure of the "knower" is not at all disembodied: The names of Éric Calais, Steeve Symithe, or engineer Prépetit come up frequently during the interviews. They are repeatedly cited as sources or reference authorities to justify statements or technical practices related to the use of RS. Interaction with scientists is a strength here, as the success of citizen science initiatives can hardly do without discussions between citizens and scientists (Fallou et al. 2020).

Overall, the interviews indicate that the presence of the researchers is considered a guarantee of trust. As the S2RHAI project›s approach is based on exchanges and reciprocal listening between seismologists and RS hosts, even though the researcher remains the referent, the experience tends to position the RSs as tools that make it possible to become aware of everyone›s knowledge—cognitive knowledge, validated by science; but also knowledge-being, validated by society and all a person's cultural influences; and knowledge-doing, validated by work—each as legitimate as the other (Héber-Suffrin 1993). The project approach tries to find the balance between situated knowledge (Haraway 1988) and socially relevant knowledge, the one that interests the citizens (Lemos et al. 2018).

On the whole, the hosts show a feeling of belonging to this social-seismological network under construction, although they do not necessarily consider themselves on the same level as other participants, and they establish mental hierarchies based on their perception of each other's knowledge. While some are satisfied with their level of involvement and do not wish to become more involved, all have made requests to improve not only the project but also the network as a whole and its sustainability. These requests are intended to enable them to go further in their knowledge of scientific facts and in their usefulness to society as a whole. They also embody the need for balance in the relationship between the experts recognized as such (the "knowers") and those who are recipients of the system (the hosts).

Another interesting point is that, two years after the beginning of the project, volunteers took advantage of the interviews to talk about the concrete difficulties they encountered and to outline possible improvements. We identified various requests that RS hosts felt were necessary to better understand the system and to play their role as fully as possible. We list hosts' requests for support and their suggestions for the project improvements in Appendix 3. They specifically asked for support of three kinds: technical, scientific, and educational. These requests are considered in the continuation of the project, with technical assistance of course, but also better training and scientific discussion, greater consideration of pedagogy (including school students), and further education on RS and earthquakes, in order to better understand and disseminate the project.

CONCLUSION: UNDERSTANDING CITIZENS' NEEDS TO REINFORCE THEIR INTEGRATION IN THE SOCIO-SEISMOLOGICAL NETWORK AND TO EMPOWER THEIR CITIZENSHIP

What are the next steps for the project after these analyses? Funding from the French National Research Agency (ANR) will make it possible to continue the project and to extend it on a larger scale, with more RS stations installed in the country across a broader socio-economic sample of the population. It will provide more assistance to the hosts, improve the communication network, and better support hosts in their role as ambassadors. Indeed, they are privileged relays to pass on information to their communities, which for the moment are not benefiting from the potential outcomes of the project. The idea is to maintain individual links between hosts and scientists while improving the collective dynamic—being part of a common project, of a research group, but also of a community.

In addition to these improvements derived from the interviews with the hosts, local institutions, in particular schools, will be included in the next step of the project, which will add a dimension of citizen science and education for young Haitians. Having the RSs in schools should be accompanied by training for teachers and pedagogical presentations to ensure the sustainability of the project (see Subedi et al. 2020, in Nepal, for instance). Institutions other than the current project collaborators will also be considered, as long as they wish to participate in public information, always with the aim of greater participation and better dissemination of knowledge.

During the discussions within the S2RHAI multidisciplinary team, another request emerged: Scientists need to better understand the socio-cultural, economic, and political context of the hosts in order to better assess local acceptance of the RSs and their data, to better adapt their scientific discourse and communicate more effectively. As of now, although the project aims at a co-construction with the hosts, the dialog still remains asymmetrical, as demonstrated in the interviews that highlight the authority attributed to scientists. Some researchers are open to questioning or even changing their communication methods after gaining a grassroots perspective from RS host interactions. Our future research will also investigate how scientists accept, or not, the so-called "non-expert" knowledge and the socio-cultural constraints of the environment where their research is applied. It will demonstrate how cognitive knowledge is associated with knowledge-being in our citizen science approach. Finally, the desire for knowledge of the local socio-cultural environment also stems, for scientists, from their need to be more useful to the citizens of Haiti, that is, to know them better in order to help them better.

Although the interviews already provide an initial response to this request, there remains an aspect that has not yet been explored: the magical world. The methodological framework was not ideal (a telephone interview with strangers), especially since the hosts mostly come from an educated part of the population, more reluctant to evoke or refer to the invisible world, and more interested in learning about science. Yet, the world of the "outside" is very present in Haiti where, whatever the religious practices, the vodou belief in acting spirits is very strong (Hurbon 2014). Called "lwas," these spirits are versatile and difficult to control, and their actions are complicated to interpret (even for Vodou masters: male *hougans*, female *mambos*). The earthquake, the RSs, the deaths, are all subject to interpretation between causes and consequences: The presence of the RSs, for example, could cause earthquakes, but the latter could also be the result of the anger of a spirit. Dreams are a medium of information, whether premonitory (warning of danger) or explanatory (making the dead, the spirits, or the forces involved in the disaster speak). This intangible world is important for the hosts as well as for those around them, for whom earthquakes are perceived from the angle of culture and risk rather than from a purely scientific perspective.

Accounting for this and accompanying the scientists in their understanding of the local culture is therefore a request, out of interest for the country, and out of necessity for optimizing the project. This will make it possible to consider not only the origin of the risk, but also the beliefs about its origin: The interviews evoke a multi-causality of a disaster, and remind us above all that these are diverse, cumulative, and can occur at any time. The unpredictability of the disaster is erased by the permanence of the risks and dangers hanging over Haiti. The earthquake, which can be major in its scope, is one disaster among many others of all kinds: floods, cyclones, political and economic crisis, insecurity, etc. In Haiti, there is therefore no society of risk, but risks (Hurbon 2014). These accumulate in daily lives, where the various ordeals that everyone may encounter are intertwined. This accumulation of risks is so deeply rooted in Haitian reality that it gives rise to day-to-day adaptation processes: The "do it yourself," or tinkering, of daily life allows individuals to be highly reactive in the face of a disaster, whatever it may be, and to integrate impromptu events into ever-changing parameters of

existence (Corbet 2014; Schuller and Morales 2016). These individual and collective coping mechanisms evolve with the events that the population encounters, making them apparently "resilient," a term we use with caution because there is no normality to which people would return after a trauma, instability being the norm.

Among the environmental risks, tsunamis are quite frequently cited, even though the associated risk is quite low: There was a tsunami associated with the 1842 earthquake in Cap Haitian, and a micro-tsunami in the area of Leogane (related to a landslide) after January 12, 2010. This high level of evocation of the impressive phenomenon of the tsunami, especially in a coastal country, may be a consequence of the large information campaigns sponsored by UNESCO in the region.

Finally, better information on Haitian beliefs would allow for a better understanding of the fears and traumas of the hosts as well as of the Haitian population, and thus adapt the seismological information to raise awareness of natural risks without rejecting scientific knowledge or increasing fears. Indeed, it will be necessary to avoid bringing back memories that are too difficult for people for whom earthquakes are deadly realities, who have already experienced them, and who may hold that trauma in their bodies—all of this within a society that makes constant reference to them. For example, the rubble of the 2010 earthquake is still present in the urban landscape, people experience nightmares as a result of trauma, and allusions to the missing are omnipresent (Corbet 2014).

To answer some of these questions, the continuation of our project will include more Haitian institutions, will diversify places and types of hosts to better understand and adapt to the local culture, and will be more inclusive—while helping the State and its institutions improve their technical capacities. All of the project's actors, especially those from outside the country, are aware that even if the Haitian state is often described as "failed" (Verlin 2014), it must nevertheless be included in international and national projects so as to strengthen its capacities and to avoid any suspicion of intrusion or interference in Haiti.

Our analysis focuses on the first steps in establishing a seismic network in an economically, socially, and politically challenging environment, in collaboration with citizens who are part of it. Setting up and consolidating such a network, in the broadest sense, will take time, and the issues must be considered over time to ensure the sustainability of this endeavor. The continuation of the project will be based on the first encouraging and instructive feedback presented above. Some conclusions are not surprising, such as the influence of local culture and the demand for a more interactive approach, but the conclusions were very resolutely affirmed, and the citizen dimension appeared with force. The project is certainly small in scale, but we heard positive echoes that show real pride and commitment, from the hosts as well as from the researchers. This emerging network between citizens and scientists must be strengthened, for example by more attractive communication tools, and deployed more broadly, with an increase in the number of RSs, particularly in schools. It will also be a matter of individualizing the relationships with hosts, with consideration given to motivating individual investment while continuing to promote and develop a nascent collective dynamic.

Finally, the citizens' comments gave us a lot of information that allows us to better adapt the continuation of the project. It can succeed only with the cooperation of all, and this requires mutual listening and learning. A reciprocal curiosity is required to allow for a dialogue around an object (here, seismology embodied by the RSs) and to develop scientific questions geared toward all relevant aspects of seismic shaking, from the measurement of the ground vibrations to the psychological traumas of the population. We conclude that, in a citizen seismology project, understanding the motivations, obstacles, and expectations of the volunteers is essential to increase the chances of project sustainability.

In short, our collaborative project, which places the citizen at the center of the process, recognizes from its methodological approach that the echoes between the geological faults and the cultural dimension are elements that, through their crossed views, will allow us to be more effective, more accountable, more committed, and in short, better "citizens." In a context in which the very notion of citizenship is being eroded as the capacities of the Haitian State, particularly the regalian ones, are disintegrating (Duval 2021), this is an even more crucial issue. If the 2018 seismic crisis in Mayotte demonstrated how citizen science can compensate for the lack of formal scientific information (Fallou et al. 2020), perhaps the case of Haiti shows how citizen science can compensate for a lack of state will and resources.

NOTES

1 Each quote has been translated by authors. Original quotes are provided in Appendix 2.

2 Eric Calais, seismologist, coordinator of the S2RHAI project, who installed the RS at this host.

3 Claude Prépetit, a Haitian geological engineer, partner of the S2RHAI project.

SUPPLEMENTARY FILES

The Supplementary files for this article can be found as follows:

- **Appendix 1.** Presentation of S2RHAI and methodology. DOI: https://doi.org/10.5334/cstp.481.s1
- **Appendix 2.** Original quotes. DOI: https://doi.org/10.5334/cstp.481.s2
- **Appendix 3.** Hosts' requests for support and suggestions for the project improvements. DOI: https://doi.org/10.5334/cstp.481.s3

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COMPETING INTERESTS

The authors have no competing interests to declare.

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