Ethnobotanical research under the COVID-19 pandemic: assessing a remote method for documenting Indigenous plant-related knowledge

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Research

Abstract

Background: In response to the limitations on fieldwork imposed by the COVID-19 pandemic, we describe and assess a remote method for documenting plant-related knowledge, using smartphones that requires no in-person interaction between an on-site Indigenous community and off-site researchers.

Methods: The on-site team identified the Indigenous taxa, created equivalents of photo vouchers, and recorded their names and uses as voice messages using a smartphone, thereby learning about plants from one another. They then sent the data using WhatsApp messages to the off-site team, who identified the botanical names of the taxa, and analyzed the plant-related knowledge.

Results: We assess the remote, collaborative, and transdisciplinary quality of the method, factoring in communication, audiovisual documentation, species identification, knowledge exchange, logistics, and ethics. Despite the problems we experienced with identifying taxa growing in high forest and translation issues that complicated the documentation of plant uses, the method was on the whole a success. It allowed the on-site team to activate their passive knowledge of their language and share their knowledge with their relatives. The off-site team identified 57% of the recorded 54 taxa to species level and documented their names and uses as primary audio data, which keep on enhancing the quality of the documentation.

Conclusions: Smartphones can be used as research tools during periods of restricted physical access, but also to extend research beyond the fleeting field visits and to elevate the empirical standard of ethnobotany when it comes to language data. We see such remote research solutions not as replacements for in-person collaborations, but as valid and dynamically evolving research methods in their own right.

Keywords: smartphones, empiricism, photo vouchers, Taruma, Wapichan, Guyana

Background

The COVID-19 pandemic has had a devastating impact on the world, especially its Indigenous population (Power *et al*. 2020). Indigenous people experience increased vulnerability to diseases such as COVID-19 due to the more limited access to medical facilities in impoverished and rural areas. Speaking lesser-known languages, they are also often cut off from important news delivered by the media in the official languages of the countries they live in. Their vulnerability to COVID-19 has been even higher in places where the severity of the pandemic is denied by the authorities (Ferrante & Fearnside 2020). The global health crisis has also affected scientists working with Indigenous people (Forrester 2020). Ethnobiologists, linguists and other researchers often work with Indigenous communities, sometimes in a different country or even on different continents, and under normal circumstances interact with their inhabitants directly (Vandebroek *et al*. 2020). For such external researchers, the pandemic has entailed reckoning with the health risks for the parties involved in research and travel restrictions, including those enforced by the universities through their newly adapted permit systems. Consequently, when face-to-face encounters are a challenge to organize, Indigenous people and external researchers are limited in their capacity to exchange knowledge.

To an extent, this is not a new problem: scientists have faced similar restrictions on working in conflict-affected areas for decades. The value and use of social media as a communication tool for plant scientists has been discussed extensively (Osterrieder, 2013). It is our contention, however, that technology, both when it comes to its functionalities and availability, is changing fast. At the same time, the pandemic has catalyzed several digital initiatives in academia (e.g., online education). It also brought to the academics' attention the fact that Indigenous people are present online. A good example of that from Guyana, the country where the present study was carried out, was the *Public discussion of family language policy* in 2021 at the University of Guyana, an event attended by the representatives of the country's Indigenous nations on their smartphones. It is this climate that led us to search for alternatives to fieldwork-based research. *Remote research*, that is, research conducted virtually using digital technology with no in-person interaction between participants (Douedari *et al*. 2021; Vandebroek *et al*. 2020), can offer a solution to constraints on in-person fieldwork. In this vein, we report on a remote method for documenting plant-related knowledge developed by Indigenous people living in Guyana and researchers from the Netherlands and the US. Our main goal is to present the method and discuss its advantages and disadvantages. To do so, however, we first review how research, ethnobotanical research in particular, is typically conducted.

The standard procedure botanists use to document plants, the origins of which date back to the 16th century (Stefanaki *et al*. 2018), is to interview people on site, collect plants, process them into *physical vouchers*, deposit those at a herbarium, and establish their botanical names by comparing the material with existing vouchers, illustrations, and descriptions (Culley 2013; Penn *et al*. 2018). The procedure creates lasting records of primary data (i.e., plant vouchers), enables revisions of the proposed identifications, and provides records of the plants' traits at a given place and time. Since such vouchers contain genetic material, they can also be used for other analyses, e.g., intraspecies genetic variation (Heberling & Isaac 2017). While of great importance to botany, physical vouchers also have limitations. Some plants, such as palms, are difficult to preserve and store due to their physical characteristics (Martin 2007). Moreover, preparing the vouchers requires considerable labor, equipment, training, and permits to collect and export the biological material. Obtaining such permits may take time, making it impossible for students to secure them in time for their projects (Forrester 2020). Storage of vouchers, which requires space and funds, has also become a concern for herbaria around the world (Schilthuizen *et al*. 2015). At the same time, many academic journals, such as *Economic Botany*, require the contributors to refer to numbered physical herbarium vouchers, which allow for controlling and duplicating the results. Crucially, given the above limitations, in particular the required tools and training, physical vouchers are difficult to collect remotely.

Instead of physical vouchers, a less common method for documenting plants relies on photographs. Using photographs, the researcher records the same features of the plants- leaves, stems, flowers, fruits, and other distinguishing features- and follows the standard procedure for establishing their botanical identification (Gómez-Bellver *et al*. 2019; Greene *et al*. 2023). Such *photo vouchers* also contain all the metadata that physical vouchers do, like collector, date, location, and in ethnobotany, the local names and uses of the plant (Martin 2007). There are benefits to using photo vouchers. They permit recording a plant in its natural habitat and do not entail removing it, which may be impossible due to its cultural significance or endangered status. Digital photographs are also easier to collect, store, and share than physical vouchers (Thomas *et al*. 2007). Macro-photography, which requires special equipment and training, can even offer extreme close-ups (Amith 2021; Thomas *et al*. 2007). However, photo vouchers do not provide genetic material, nor texture, and may not show smaller traits such as hairs, which rules out further detailed research (Heberling & Isaac 2017), and journals are reluctant to publish research based on them

(Greene *et al.* 2023). Yet, since high-quality photographs can today be taken by anyone with a smartphone, photo vouchers are a potential fit for remote research, a possibility we explored in more detail.

Irrespective of the method, the type of data studied (plants) renders botanical work visual in nature. Collected or photographed, plants are first compared visually to other material to identify them. However, the more interdisciplinary field of ethnobotany not only *looks at* plants, but also *listens to* their Indigenous names and uses. Yet, if ethnobotany stands firmly on its empirical footing when it comes to the visual material, stored as primary data, such as physical or photo vouchers, its standard for recording sound is less rigorous. To record plant-related knowledge, ethnobotanists conduct in-person interviews, usually through an interpreter, leading to publications for a public speaking a major language, such as English. Indigenous names and uses are usually reported as secondary data: the researcher's perceptions of what they heard and translations. Primary audio data, that is, publicly accessible recordings of naturalistic speech, a standard in language documentation since Himmelmann (1998), are rarely produced. This creates the risk of misrepresenting knowledge enmeshed in Indigenous languages, and rules out using the data for other purposes, including the verification of the results. Digital by default, remote research favors the creation of primary data, encouraging visual and auditory empiricism, and amplifying the utilization potential of the output. This, however, calls for a clear archiving plan for the dataset: prior decisions about file formats, metadata, long-term storage, etc.

The rigorous standards and restrictions can limit research in remote areas. In addition, Indigenous scholars stress that in the context of marginalized people speaking moribund languages, projects following the common subject-object format, whereby outsiders study the knowledge of locals, typically elders, is often inappropriate (e.g., Hall & Smith 2000; Loukotka 1949; Ormiston 2020). The familiar focus on the knowledgeable elders often leads to younger people, who may not speak the language, being excluded from the project, adding to the linguistic and cultural gap between the generations. Scientists have a history of producing output for the community (product-centered research), which runs the risk of misaligning research from community needs, rather than involving the community in research to create a space for capacity building, transmission and vitalization of their knowledge throughout the project, which is true community-centered research (Bischoff & Jany 2021; Martins 2021). Under the conditions of language loss, an outsider asking questions can even dispirit participants by pointing out the gaps in their expertise. Today, researchers break away from this paradigm and design work in collaborative and decolonial ways, incorporating the values, knowledge, and goals of all the parties (Martins 2021). These familiar challenges, however, must be taken up anew when considering new forms of research. Given the above Indigenous experience of research, particular attention needs to be paid to the design of remote research, whose virtual nature may grant a more active role to the Indigenous participants, but also creates the risk of introducing socially awkward, culturally inappropriate, and out-right unethical practices.

Exploring alternatives to traditional fieldwork, we turn to smartphones since they are commonly used by Indigenous people as the main means of accessing the internet, offering new forms of education, communication, entertainment, and so on (e.g., Dyson & Brady 2009; Ferreira Filho 2019). While decreasing purchase costs of prepaid phones made them popular with Indigenous people, their use by Indigenous communities has its own peculiarities. In many developing countries, however, phones are shared, rather than private, devices, which may have consequences for the security of personal and research data (Katusiime & Pinkwart 2019). Plant-related knowledge itself may be seen as specialist or secret knowledge that should not be shared with everyone, the main concern of the village council of the community we work with. There are also various ways to use phones in research (Osterrieder 2019). The method presented here is partly inspired by plant identification applications, such as iNaturalist, that use crowd-sourced data to record and identify species. Such citizen science applications, however, work well in places where plants are well studied and photographed, such as Western Europe, not in understudied biodiversity hotspots such as the Amazon rainforest (Greene *et al.* 2023). In contrast to messaging applications like WhatsApp, such applications also preclude the back-and-forth communication among project members that ethnobotanical research requires (Bonney *et al.* 2014; Cohn 2008; Geldmann *et al.* 2019).

Mindful of the above theoretical and methodological standards, we report on a remote, collaborative, and transdisciplinary method for documenting plant-related knowledge. The method was developed by the elderly speakers of Taruma and their younger Wapichan-speaking relatives and friends living in Maruranau, one of the villages in *Wapichan Wiizi*, the "Wapichan Country", as well as researchers from the Netherlands and the US (Fig. 1). We describe first the project's sociolinguistic setting and the goals of the three parties involved.

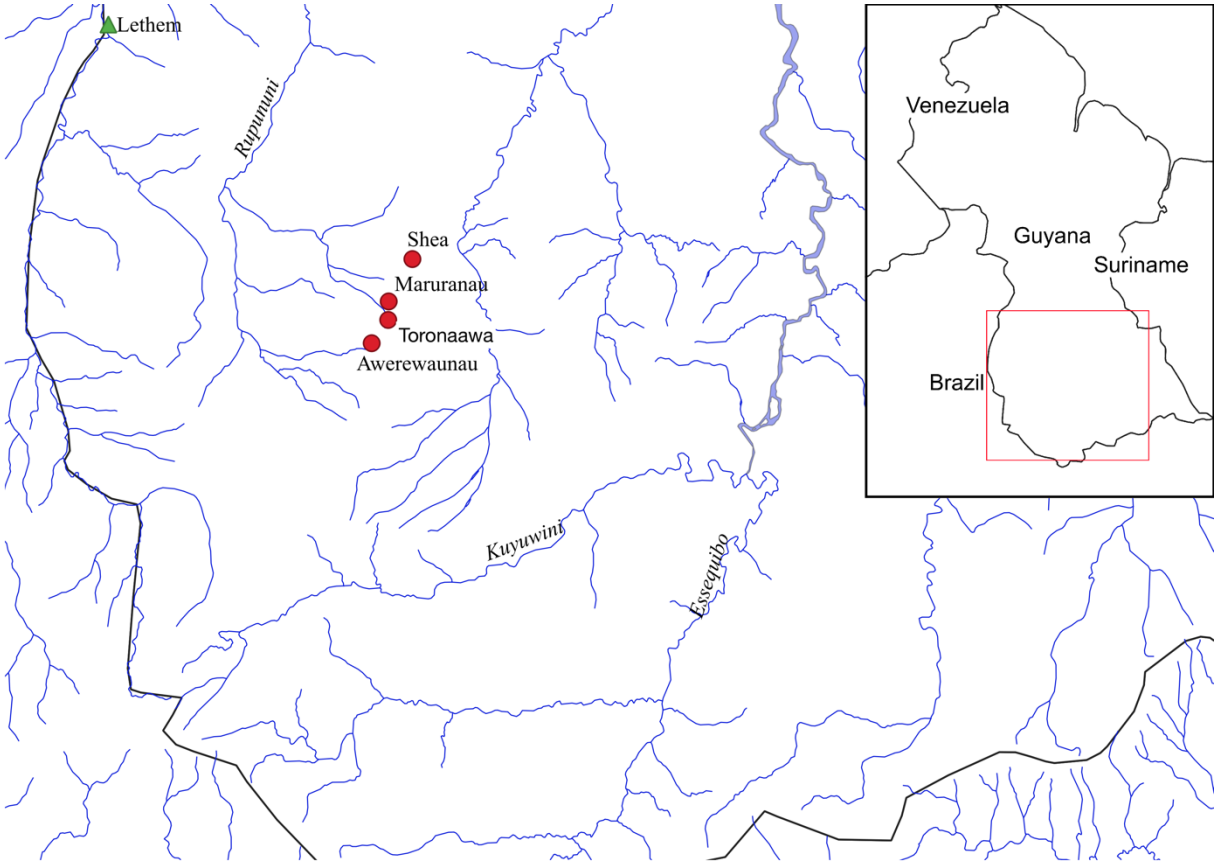

Figure 1. Location of Toronaawa and nearby places in southern Guyana. Map created with QGIS (QGIS Development Team 2020).

It is generally assumed that interethnic wars and diseases devastated the Taruma nation (Rivière 1966). The last Taruma live among the Waiwai and Wapichan people. The last three Taruma speakers live in Toronaawa, an hour's walk away from the center of Maruranau, a Wapichan village in the Upper Takutu-Upper Essequibo region of Guyana (Carlin 2011). As such, today they form part of the Wapichan society (Henfrey 2002; Gomes 2022). The Taruma, who call themselves **Hodjasu** 'People' in their language, speak Taruma, a language that is unrelated to any other language, and Wapichan, an Arawakan language. Their younger relatives and friends speak Wapichan and (Guyanese) English, the official language of Guyana. The Taruma speakers involved in this project wanted to document their knowledge and pass it on to their relatives, who in turn wished to start learning their heritage language.

Wapichan (often spelled **Wapishana** in the literature), while spoken by all generations, loses ground to English, a threat recognized by the communities (Gomes 2022). Consequently, the Wapichan Literacy Association, a language-related association of the Guyanese Wapichan, has piloted bilingual education, literacy workshops, and published Wapichan-language materials. While the association wants to use digital tools for educational purposes, it is aware that they are the domain of major languages. One of its goals is therefore to build capacity for creating Wapichan-language digital content, so that the Wapichan can benefit from what the digital world offers while fostering their culture. The Wapichan involved in this project wanted to acquire skills useful to language-related work, such as digital and translation skills.

Taruma is virtually undocumented: data are limited to Farabee's (1918) short wordlist and Fr Cary-Elwes' unpublished notes (Butt Colson & Morton 1982). Except for a few names and uses noted in Yde's (1965) work on the Waiwai, Taruma plant-related knowledge remains undocumented. While Wapichan language and culture are better known to outsiders (dos Santos 2006; Henfrey 2002, 2018; Wapishana Language Project 2000), the documentation leaves much to be desired. The researchers wanted to document the plant-related knowledge of the Taruma and Wapichan, who still cherish much of their plant-based culture, kick off the description of Taruma, and shed light on the past contacts of the Taruma by identifying plant names shared with other languages. The pandemic forced them to explore remote research solutions, adding to their goals the assessment of the methodology.

The method was developed by the Taruma and the Wapichan researchers (henceforth "the on-site team"), and researchers from the Netherlands and the US (henceforth "the off-site team"). In broad strokes, the on-site team photographed plants, creating equivalents of photo vouchers, and recorded their names and uses as voice messages with a smartphone. They sent the data via a messaging application to the off-site team, who identified the botanical names of the taxa and analyzed the Taruma plant-related knowledge. The transdisciplinary and collaborative nature of the project is reflected in design details that foster the intergenerational transmission of knowledge, the sharing of language-related skills, and the creation of visual and auditory primary data stored locally and in a professional digital archive, and therefore accessible to all parties for research and other purposes. In what follows, we describe the method, paying particular attention to the digital tools we used, and assess its remote, collaborative, and transdisciplinary design. In doing so, we offer several useful guidelines for carrying out similar projects, especially with students in mind. We hope that our insights indicate what hurdles occur during remote research in areas with high botanical diversity and with partners with little experience with digital tools. Despite the problems we experienced with identifying species growing in the rainforest and documenting the details of the recipes for the preparation of plant-based products, we expect our outcomes to inspire ethnobotanists to employ smartphones more often as research tools, not only during periods of restricted physical access, but also to extend research beyond the fleeting field visits. We see such remote solutions not as replacements for in-person collaborations, but as valid and dynamically evolving research methods in their own right.

Materials and Methods

Since the present authors constitute the project's team, we use our first names to discuss our roles. The project began when Konrad, a researcher specializing in the Indigenous languages of the Guianas, asked Adrian, the coordinator of the Wapichan Literacy Association living in Maruranau, to investigate the interest of the Taruma in sharing their plant-related knowledge. Two Taruma speakers, Irene and Vincent, and their Wapichan-speaking relatives, Elizabeth and Nita, expressed their interest in the project. Konaukii, a Wapichan teacher of English from Maruranau, joined the team to gain experience in language-related work. Adrian coordinated the activities of the on-site team. Anna, a linguistics student, focused on Taruma phonology and orthography. Robin and Anne Marie, ethnobotany students, and their supervisor, Tinde, a researcher specializing in the ethnobotany of the Guianas, helped identify the species and formulate follow-up questions that could help in the process.

Setting up a virtual collaboration

The project was set up remotely during the pandemic (April to December 2021), using a messaging application; most of the off-site researchers have not met the on-site team in person at the time. We chose WhatsApp because it is easy to use, allowed us to share various content, and was familiar to most of us. A WhatsApp group was created to discuss the project. We started with introduction videos about ourselves and our roles to familiarize ourselves with the functions of WhatsApp (Table 1). While Adrian and Konrad had live calls, much of the communication was not live: the on-site team responded when they had access to the hotspot in Maruranau. The off-site team had a separate WhatsApp group and online meetings, as access to the campus was not allowed at that time. To conduct the research, money was transferred to Adrian, who managed payments of the on-site team. To photograph plants and record their names and uses, Adrian bought a Samsung A21S phone and rubber boots for the Taruma participants to safely walk in the forest, which were all donated to the Taruma at the end of the project.

Table 1. Location and tasks of the on-site and off-site team.

Team	Participant	Tasks
on-site	Irene Suttie	identifying Taruma and Wapichan useful plant taxa
	Vincent Louis	identifying Taruma and Wapichan useful plant taxa
	Elizabeth Louis	audiovisual documentation, Wapichan-English translation
	Nita Louis	audiovisual documentation, Wapichan-English translation
	Konaukii Gomes	sorting and uploading the photographs and recordings
	Adrian Gomes	coordinating research locally and budget keeping
off-site	Robin Bredero zur Lage	botanical identification and linguistic comparison
	Anne Marie Holt	development and evaluation of the methodology
	Anna Serke	linguistic analysis
	Tinde van Andel	supervision of ethnobotany students
	Konrad Rybka	project coordinator, linguistic analysis

Training via WhatsApp

Besides Adrian and Konaukii, the on-site team had little experience with smartphones. Since they were to perform all the field tasks, at least a minimum of training in documenting plants, their names, and uses was required. The off-site team offered basic training via WhatsApp. Robin, Anna, and Konrad sent text and audiovisual instructions,

with examples, on how to photograph plants and record their names and uses. The on-site team responded with photographs and recordings, which the off-site team evaluated, offering suggestions for improvement. Given the high biodiversity of the area, it was agreed that the documentation would begin around the house, in disturbed habitats with common weeds, small herbs and domesticated plants, which are easy to identify botanically, and gradually move into the savanna and forest to document wild and larger plants (lianas and high trees), generally more difficult to identify from photographs.

Photographing plant taxa

The photo voucher method required capturing the entire plant, with a person in the picture for scale, leaves, trunk, bark, and other distinctive features, such as flowers or fruits that could aid the off-site team in identifying the taxa (Fig. 2). The on-site team embarked on field walks to locate and identify plants used by Taruma and Wapichan using their own criteria, as evidenced by photographs showing bark cuts made to identify the trees by their smell, taste, or color, a common Indigenous technique for identifying plants. To stimulate the transmission of such knowledge across the generations, they were to work as a team of four. Encouraged to modify the method as it suits them, they split into two speaker-learner pairs. Vincent, assisted by Nita, and at times Elizabeth, went out to photograph the taxa. Unable to walk far, Irene worked with Elizabeth at home, using the photographs to identify the plants independently.

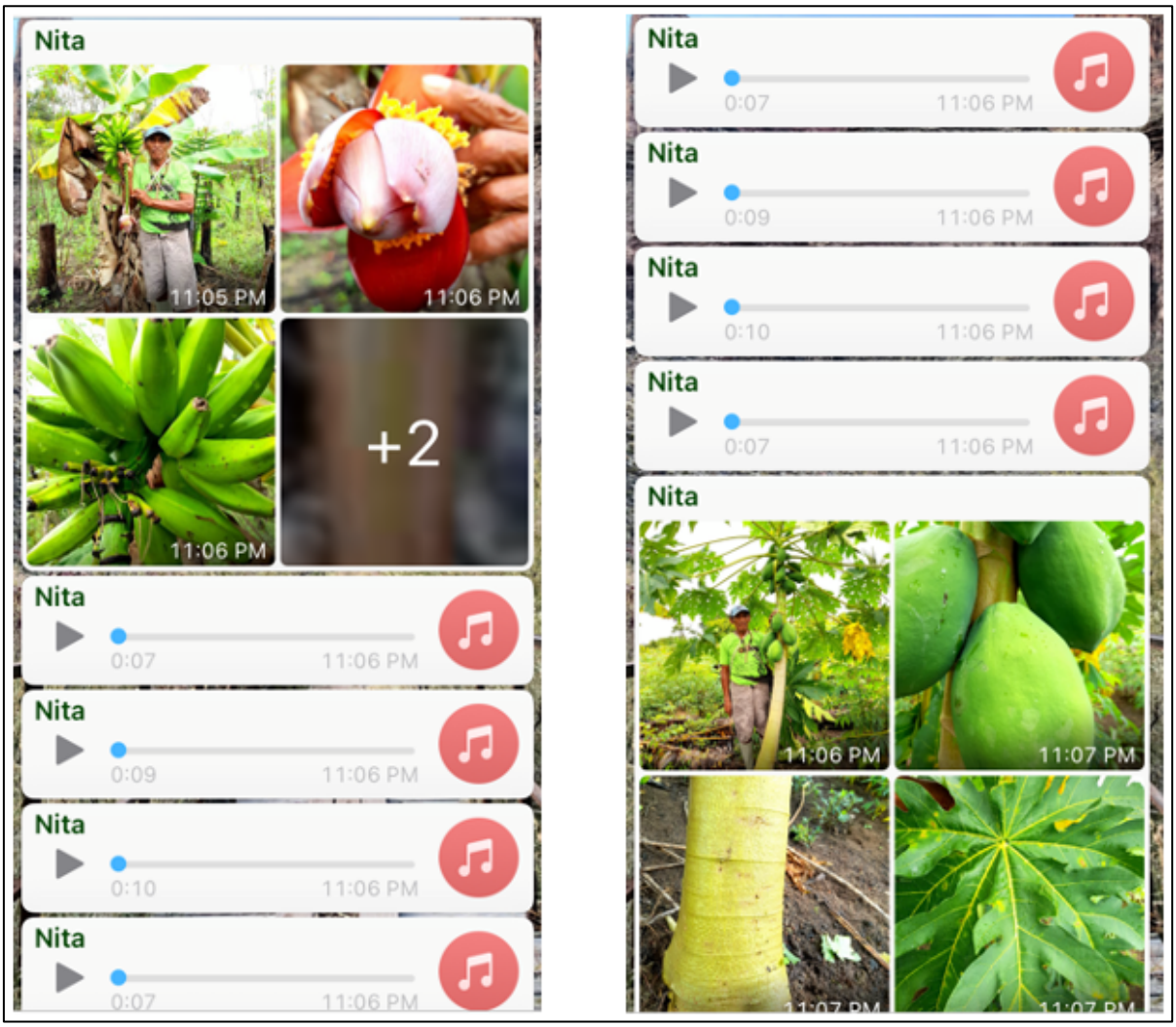

Figure 2. Examples of the photovoucher and audiovisual data for a banana variety (*Musa* sp., top left) and a papaya tree (*Carica papaya*, bottom right).

Recording names and uses

The on-site team was also to record the names and uses of the plants. To do so, they first used WhatsApp voice messages, but soon found the recorder application easier to use. They recorded the Taruma, Wapichan, and, if known, the Guyanese English name of each taxon as separate recordings. In each recording, the names were

repeated three times by the speaker and three times by the learner. The repetition was meant to make the intergenerational transmission of the languages explicit, capture difference in pronunciation, and assure that the off-site team hear the name clearly in its full form. In Wapichan, for example, word-final vowels are often dropped. When words are repeated, there is a higher chance of the vowel being pronounced and the whole name being documented. The same strategy was used for recording plant uses. Occasionally, the on-site team also included photographs of plant-based products.

Transferring the data

Data collection continued from mid-April until July 2021. The phone signal in the area is not strong enough to use the cellular network for transferring photographs and audio recordings. For this reason, the documentation was created offline, and sent via WhatsApp when the team was at the hotspot in Maruranau. Consequently, the uploads contained data collected over weeks. Since the team created multiple photographs and recordings in Taruma, Wapichan, and English, it was important that the data associated with a single taxon were organized per plant first. Sending the files in the wrong order could lead the off-site team to associate wrong names and uses with a given plant. For this reason, Konaukii, Elizabeth, and Nita were to make sure to assemble the data correctly, before sending them to the off-site team.

Processing the data

Robin and Anne Marie downloaded the files using the desktop version of WhatsApp and renamed them in line with archival file-naming standards (Kung *et al.* 2020); only letters, numbers, and underscores were allowed, for example, as some programs fail to process files with names that contain other symbols. Since the on-site team recorded several messages per taxon, to efficiently work with the data, Robin used a Python script to concatenate them, convert them to the WAV format, and create corresponding ELAN files (Appendix 1). ELAN is a software for annotating recordings, using custom tiers, including transcriptions time-aligned per speaker and language, allowing us to study the speech of each participant (Sloetjes & Wittenburg 2008). Konrad used DaVinci Resolve, a free video editing software, to turn the recordings into videos with time-aligned photographs of the plants and their Linnaean names later added by Robin (Fig. 3).

Assembling audiovisual vouchers

Next, the off-site team created what we will refer to as *audiovisual vouchers*: photo vouchers with embedded audio. We used PowerPoint to assemble the vouchers, including all the photographs of the taxa. The metadata included the standard metadata used by botanists (e.g., location, date, species' identification), but also Indigenous knowledge- the Taruma and Wapichan names and uses- enhancing their useability to the community and larger audiences. Similarly, we included the names of the people responsible for the Indigenous classification and documentation of the plants, and those responsible for the botanical identification and transcription. Konrad exported the vouchers as pdfs and used Acrobat Reader to embed the WAV files with the Taruma and Wapichan names of the taxa in the pdf (Fig. 4, Appendix 2).

Analyzing the data

To identify the plants, Robin consulted floristic literature, online herbarium databases of the Naturalis Biodiversity Centre and Global Biodiversity Information Facility, and experts on the flora of the region (Bredero zur Lage 2021). Since not all plants were photographed well, he asked for more photographs when needed. He then added the identifications to the audiovisual vouchers and ELAN files. The data were analyzed from several angles. Robin compared the Taruma plant names to those in other languages to identify shared words and, by extension, past contacts of the Taruma people with other nations (Bredero zur Lage 2021). Anna used the data to study Taruma, propose an orthographic standard for the language, and write an account of its phonology. Anne Marie wrote an evaluation of the method for her MSc thesis (Holt 2021), which formed the basis of this article.

Evaluation and archiving

To evaluate the project, the off-site team prepared guidelines for an evaluation interview, which Adrian used to discuss the collaboration in person with the on-site team and draw up their feedback (Appendix 3). After the project, Konrad and Anna were able to visit Toronaawa to further document the languages, meet the on-site team in person, and discuss the project. The videos and audiovisual vouchers were deposited at the computer hub in Maruranau to further stimulate the Taruma and Wapichan learners. Finally, Anna organized all the audio, video, and pdf output, and created appropriate metadata files required by the Endangered Languages Archive (Berlin), using Lameta, a free metadata program for organizing data collections. Once the on-site team defined the access rights to the data,

the complete documentation was deposited with the archive, where it can be accessed online for research, educational, and community purposes (Rybka *et al.* 2023).

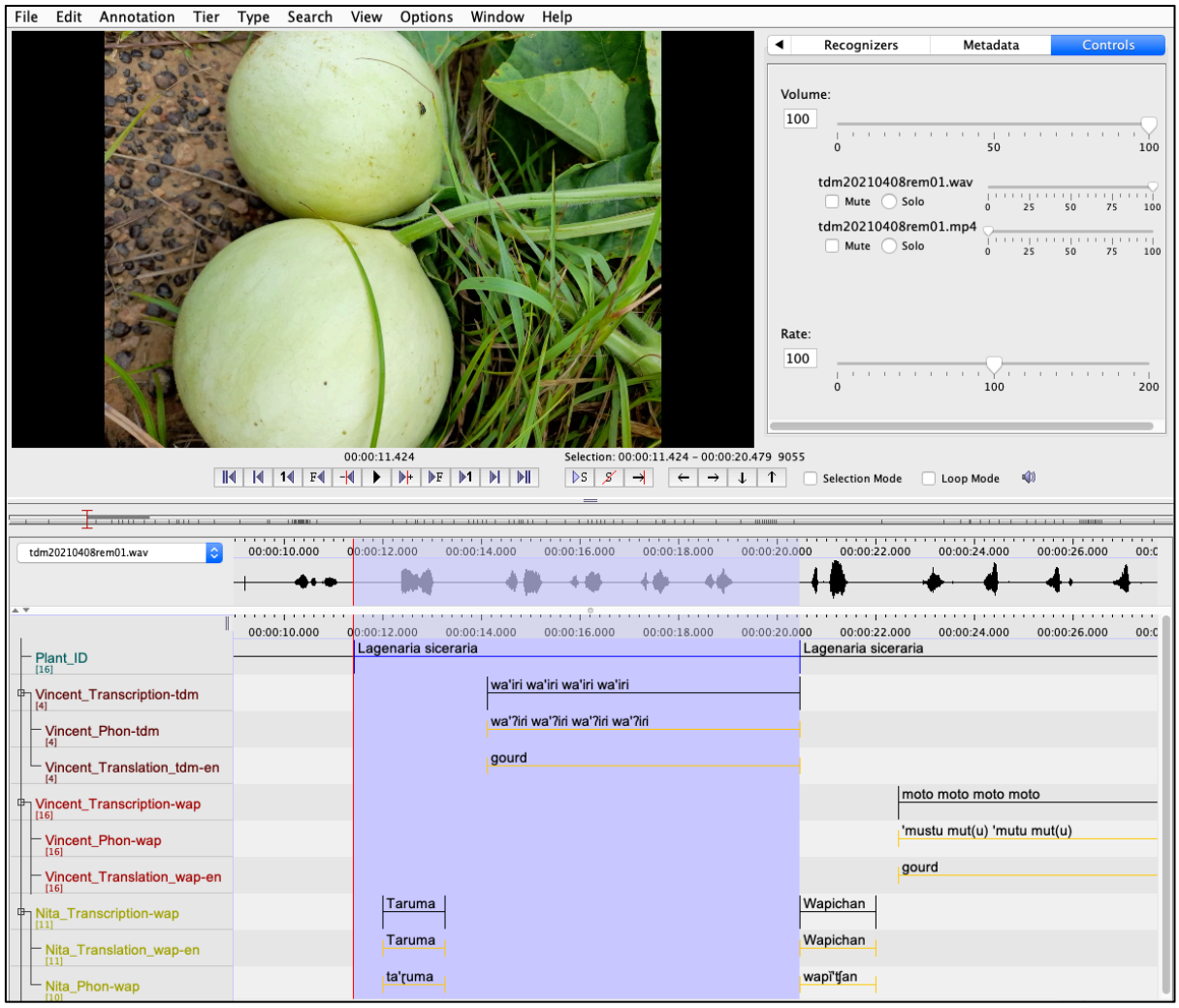

Figure 3. Excerpt from the audiovisual community product, documenting names in Wapichan and Taruma for the bottle gourd (*Lagenaria siceraria*).

Results and Discussion

We recorded 54 taxa, of which 57% were identified to species level, 35% to genus level, and 2% to family level only; while 6% of the taxa remained unidentified, as they lacked specific characteristics. We also created the first primary Taruma and Wapichan language data. While the sample is small, we note that the on-site team photographed all the plants that the Taruma remember in the vicinity of Toronaawa. More plants were said to be found deeper in the forest, some 70 km southeast, near the Kuyuwini River, where the village of Vincent and Irene's mother was once located, but an expedition there was not feasible. Admittedly, our project is but a modest contribution to the ethnobotany of Guyana. We use this experience, however, as a springboard into a more systematic discussion of remote research. To adequately address our remote, collaborative, and transdisciplinary ambitions, we organize the discussion into three broad categories: *language*, *plants*, and *partnership* (Table 2). In each of these, we reflect on the *form*, *content*, and *ethics*. When it comes to language, we take up issues related to online communication, documentation, and personal data embedded in the latter. When it comes to plants, we discuss the vouchers, the identification process, and cultural protocols. In assessing the partnership, we turn to logistics, knowledge exchange, and the overall ethical design, including informed consent. Besides ethical concerns, grouped together in one section, the remaining six aspects of the method are discussed in separate sections.

Indigenous uses:
From *wa'iri*, we make a water bottle to keep water cool. First we dry the fruit in the sun, then we make a hole in the middle, and take out the seed. Next we pour water inside and let it there for three days. Then we wash and clean it, and it is ready to use.

Identification no:	20210408_01	**Taruma:**	*moto* ['mu.tu]
Photography:	V. Louis, N. Louis, E. Louis	**Wapichana:**	*wa'iri* [wa.'ʔi.ri]
Identification (Indigenous):	V. Louis, I. Suttie	**Family, species:**	Cucurbitaceae, *Lagenaria siceraria* (Molina) Standl.
Identification (Botanical):	R. Bredero	**Date:**	2021-04-08
Transcription:	A. Serke, K. Rybka	**GPS:**	Maruranau (2° 44' 49" N, 59° 9' 31" W, ALT:309)

Figure 4. Example of an audiovisual voucher for the bottle gourd (*Lagenaria siceraria*).

Table 2. Format of the assessment.

Aspect	Form	Content	Ethics
language	online communication	language documentation	personal data
plants	photo vouchers	Linnaean classification	cultural protocols
partnership	logistics	exchange	consent

Ethics

Research with Indigenous people must adhere to academic standards, such as those of the International Society of Ethnobiology (2006), and those of Indigenous people, such as OCAP® (*Ownership, Control, Access, Possession*), which reaffirm the rights of Indigenous people to control research that impacts them, own the data about themselves, and have access to and physical control over such data. OCAP® is a registered trademark of the First Nations Information Governance Centre (https://fnigc.ca/ocap-training). Below, we look at personal data, informed consent, and cultural appropriateness.

Researchers using audiovisual tools must control for the fact that the final output can disclose participants' personal data; in a small community, the inhabitants can be identified by their voice alone. Vincent's presence in the photographs as an estimation of scale, for example, became a problem halfway through the project when he realized that he did not want to be visible in the output. While he ultimately wanted to be explicitly credited for his work, the scenario highlights the need for continuous negotiation of research, to help the team understand its short- and long-term consequences, particularly when it comes to the less familiar remote and audiovisual methods that straddle the border between private and public interactions.

Informed consent was construed as an ongoing conversation, beginning with Adrian discussing the project with the on-site team before it started, and ending with Konrad recording consent when visiting Maruranau. Written consent was incompatible with the idea of ongoing conversation. Further, recording verbal consent remotely would require a better internet connection for live conversations. Language constituted another obstacle, since the Taruma speakers do not speak English. In the end, we recorded bilingual consent in Wapichan and English as audio files deposited in the archive. However, verbal consent in a minority language is not always accepted by ethics boards, a problem to be addressed at the start (Granadillo 2011).

To make sure that the project adheres to the community standards, it was submitted for approval to the village council of Maruranau, an institution overseeing research in the village; the Guyanese Ministry of Amerindian Affairs and the Environmental Protection Agency were informed about the collaboration as well. A key concern of the council was the risk of sharing secret knowledge with outsiders, especially since Vincent is a healer. In this respect, remote research puts the on-site team in a position of control over the shared data; the problem can be limited by the off-site team being made aware of their right to withhold information. Access can also be restricted when archiving the data by setting appropriate access rights on parts of the collection. In our case, most data are open access.

Remote research can also be culturally more appropriate. Ethnobotanical research is expected to incorporate "equitable sharing in ways that are culturally appropriate and consistent with the wishes of the community involved" and "be conducted in the local language" (Maroyi 2020). Our remote method is not only attuned to the needs of the community- in as much as their goals defined some of its aspects- but it also supports Indigenous languages. The support is both direct, as the method encourages the use of the languages throughout the project, and indirect, as the project produces output that can be used for learning purposes. Crucially, our multimedia output not only elevates the standards of ethnobotanical and linguistic research but is also mindful and supportive of the orality of Indigenous cultures in question.

Researchers are also "expected to have a working understanding of the local context prior to entering into research relationships with a community" (Maroyi 2020). In practice, this is impossible when it comes to student projects, who therefore run the risk of accidentally breaking cultural protocols. Among the Warao, for example, another nation of Guyana, *Ischnosiphon* species are used to plait baskets harbor spirits, controlled by specialized craftsmen, who must treat the plant with respect (Wilbert 1975). Remote research puts Indigenous people in control of the research activities, including the handling of the plants, which not only increases their involvement, but also prevents outsiders from accidentally breaking such unwritten laws.

Assessment of communication

Communication difficulties faced by the off-site team were limited to the time zones they worked in (California and the Netherlands). This, however, was beneficial for the on-site team who could contact them at different hours. The on-site team, who knew each other before the project, did not report communication issues on their side. Communication between the on-site and off-site team was initially good, though it must be repeated that the leaders of the teams were colleagues. Without such prior contacts, collaboration would be more problematic, as it is difficult to build trust with strangers over the phone. Although few on-site researchers used smartphones before, they quickly learned how to use text and voice messages to communicate for research purposes, and even introduced themselves with video messages. The audio was of high quality with little background noise, even though we did not use external microphones.

The on-site team had to speak, and translate between, three languages. This opportunity to improve language skills, however, also affected communication. The speakers lacked confidence in recording messages at first, since this was their first time speaking Taruma to outsiders, through the phone to boot, and they were concerned about not meeting their expectations; the learners felt hesitant translating Wapichan into English, which is not their first language. The method gave the team time to redo the recording, helping them gain confidence. The on-site team praised the possibility of falling back on the instructions sent by the off-site team. In the end, they appreciated that their voices were heard, and even took the initiative to record more complex texts themselves, such as the history of their family. The quality of the communication is also reflected in that the data were not mixed up in transfer, despite the fact that those uploading the data were only learning Taruma. Konaukii stressed, however, that keeping track of the order was time-consuming.

Between mid-April and mid-May five datasets were sent, but soon after the off-site team was informed that the rainy season had started and there would be no more uploads until it finished, since the rains make parts of the area inaccessible. While five more datasets arrived after the rains, communication was affected by the malfunction of the hotspot. This meant that Konaukii had to travel to Shea and Awarewaunau to send the data. Live communication was only possible at these locations and did not play an important role in the documentation. The malfunction added extra travel costs to the budget, affected the morale of the teams, and delayed the uploads and answers to the follow-up questions. But it also offered us a chance to test the method under conditions of more limited internet access. Given these obstacles, remote communication was on the whole very good.

Assessment of linguistic documentation

Since the language data were recorded, they can be studied, incrementally enriching the documentation. Both languages have unfamiliar sounds. Wapichan, for example, boasts typologically rare implosives, e.g., /ɓ/ as in **baro taba'u** /'ɓaɽu ta'ɓaʔu/, lit. "axe handle", an *Aspidosperma* tree used to make axe handles. Taruma has several palatalized consonants, e.g., /tɕ/ and /dʑ/ as in **hichi asukidjo** /'hitɕi ˌasi'kidʑo/, lit. "gray brocket's ear", a savanna shrub with tasty berries (*Byrsonima verbascifolia* (L.) DC.). All these sounds are phonemes: the smallest sounds of a language that distinguish one word from another, represented by linguists using slashes. Put simply, mistaking Taruma /tɕ/ for /dʑ/, for instance, is the same as mistaking /tʃ/ for /dʒ/ in English *cheese* and *jeez*. While the sounds were first misheard, leading the off-site team to misrepresent the names, the recordings allowed them to report them properly in the end. Plant uses, however, were often laconic and the follow-up questions rarely answered. There is evidence that language was the main obstacle. Since the communication involved untrained interpreters, we expect that self-explanatory information will have been lost in translation. The off-site team took the concept of a use for granted, while the on-site team glossed over the uses of edibles. A multilingual checklist of uses would help systematize the documentation.

Adding to the translation problems are structural differences between three unrelated languages. Both issues come to fore when comparing our final translation of [1], an excerpt from a recording in which Vincent explained the uses of the banana in Wapichan, with the original translation by Nita and the final translation by the team, included:

[1] *Suuzu wadizoonii, suuzu wakomokodonii wariwunii.*
[Nita] "The banana fruit, we drink it and we also make a wine of it."
[Team] "Banana fruit, we eat it, we blend banana into a juice and make a fermented drink."

While Nita omitted the obvious, i.e., that the fruit is eaten, more information was lost since Wapichan words tend to be semantically richer; the root **dizoonii**, for example, means in fact 'eat fruit', or as they say in Guyana 'suck fruit', and, in contrast to English *eat*, also encodes information about the part of the plant being eaten. Similarly, **komokodonii** 'blend pulpy fruit or vegetable into a drink', encodes information about the object and the action, revealing details of the recipe. Crucially, such meaning-packed words often lack simple English equivalents that an interpreter can easily resort to. This meant that some of the off-site team's questions about the recipes were pointless to the on-site team: the answers were in the original, though this did not always come across in the first translation. Such problems would have affected in-person fieldwork as well, and it is only by recording the data that we could decode the message.

Finally, the Taruma have not spoken their language actively for years and may have never verbalized the recipes before. While the remote method gave them time to practice and activate their skills, as evidenced by the fact that the recordings increased in grammatical complexity from one-liners to whole texts, it may be the case that observation rather than verbal instruction is a more common form of learning in the community. Therefore, video recordings can enhance the quality of the output and be a more culturally appropriate format for sharing the recipes with Taruma and Wapichan audiences. Audiovisual data are also preferred to audio, as they document speech and the culture-specific gestures that accompany it, capturing details that are not always verbalized (e.g., actions and measurements) and the plants in question. Video recording requires a phone that can produce HD quality video and was deemed inappropriate in this project until the teams met in person.

Assessment of the photo vouchers

The photo vouchers were assessed on both their quality and completeness. The former criterion relates to the features of the individual photographs such as focus, color, and scale. Overall, the photographs were of good quality. Even though this was the first time the on-site team took detailed photographs of plants, most photographs were in focus and the features were easily identifiable. First, in 81% of the 216 photographs taken in total, the object of the photograph was in focus; 13% had various rates of partial focus, and only 7% were out of focus. Second, most photographs included a person or hand as an indication of size, and multiple photographs of the same taxon gave the off-site team additional opportunities to estimate the size. The quality of the photographs, however, varied per location. In particular, plants growing in the forest were often more difficult to photograph because of their height and the lack of good angles to photograph them, as well poor light conditions.

The completeness of the vouchers relates to how exhaustively they documented the different parts of a plant (irrespective of the quality of the photographs). The on-site team took between two to six photographs per taxon, so the vouchers varied with respect to which plant parts were included. Most vouchers show the whole plant (94%),

leaves (81.5%), stem (70.4%), fruits or flowers (54%), and other features (35.2%). The on-site team often photographed bark cuts, which speaks to the differences between knowledge systems: the Taruma recognize trees by their inner and outer bark color, taste, or scent. There were several recurrent issues with the content. First, while many vouchers included the front and back of the leaves, 18.5% did not include any photographs of the leaves, as they could not always be obtained from high forest trees or from material that fell on the forest floor. In addition, the photographs did not always show the arrangement of the leaves on the twigs or the shape of the leaf base. The flowers and fruits of plants that were not present between April and July could not be photographed; dissected plant flowers and fruits were not photographed. Finally, the height of trees growing in the forest prohibited the on-site team from photographing the whole plant as well as some of their parts.

Assessed on both criteria, the taxa growing in more densely vegetated and less domesticated landscapes were more difficult to photograph and identify. Given the lack of professional training and a simple smartphone camera, the on-site team produced good quality vouchers, though a size and color scale would further their quality (Gómez-Bellver *et al.* 2019). When it comes to the content of the vouchers, a few recommendations are in place. To cover plant parts more systematically, it merits to draw up a multilingual checklist listing all possible plant parts with visual examples. Due attention should be paid to the fact that the concepts encoded in plant part terms can vary across languages and, even more importantly, that Indigenous photographers may intuitively direct their attention to the features of plants they find important for their Indigenous classification, which may differ from those necessary for botanical identification. In our design, an explicit checklist was not compiled, though the on-site team recorded Taruma and Wapichan plant part names as part of the documentation. The data gaps due to the seasonal availability of the fertile features can be filled given more research time. It should also be taken into account that wild trees and lianas of the floristically diverse southern Guyana forests are not well photographed and can be difficult to identify even when using fertile herbarium vouchers. To photograph leaves, flowers, and fruits of tall trees, a tree climber should be involved; physical vouchers of rare rainforest species are preferred, in particular where high quality photographic records of plants are not available for comparison.

Assessment of the plant identification

The high floristic diversity of southern Guyana remains poorly studied, so that it is in general difficult to identify species without a physical voucher (Greene *et al.* 2023). Despite this obstacle, the off-site team identified a significant number of the taxa (Table 3). We could not identify the cultivars of domesticated crops, but this is complicated even with sufficient physical material, as many crop landraces in the Guianas are incompletely described or not documented at all (van Andel *et al.* 2016). Overall, the rate of identification increased with the completeness of the photo vouchers. When included, photographs of the flowers and fruits increased the rate of identification. Although the photographs did not have a scale and some did not show the entire feature, this did not hinder the identification, as there were often multiple photographs of a single plant. The poor quality and incompleteness of the vouchers did hinder the identification of the taxa that belonged to genera with many different species, which can only be distinguished by using small details of flowers and fruits. The Taruma term **shirika**, known locally as **whitee** in Guyanese English, is associated with trees in the genus *Inga*, but plants in this diverse genus can only be identified to the species level using photographs if detailed images of the leaves, flowers, and fruits are available.

Table 3. Plant identification rates by location and taxonomic level.

Identification	Total (n=54)	Village (n=17)	Savannah (n=9)	Forest (n=28)
species	57% (31)	82% (14)	78% (7)	36% (10)
genus	35% (19)	18% (3)	22% (2)	50% (14)
family	2% (1)	(0)	(0)	3% (1)
no identification	6% (3)	(0)	(0)	11% (3)

The off-site team asked the on-site team to document plants around people's houses first. Grown in the village or farm, these plants included easily identifiable domesticated species, e.g., **kobara** 'pineapple'. Commonly-used wild palms with a wide distribution in Amazonia, such as **chiwi** 'moriche' (*Mauritia flexuosa* L.f.), **taka** 'awara' (*Astrocaryum vulgare* Mart.), and **wabo** 'manicole' (*Euterpe oleracea* Mart.), were also easy to identify. By contrast, trees growing in the dense forest were often so tall that the entire plant could not be photographed, and their leaves, fruits, and flowers were only photographed if they had fallen on the ground. As the documentation moved from around the house, to savannah, and the forest, the number of taxa identified to the species level decreased. The three unidentified species were photographed in the forest.

Assessment of knowledge and skills exchange

Next, we evaluate to what extent the project contributed to the sharing of skill and knowledge. To begin, it merits to return to the alternative subject-object research scenario. The project could have hired a Guyanese botanist to travel to the site, interview the Taruma speakers, collect plants, and identify them in an herbarium. In this design, rather than documenting and teaching their culture, the speakers would be the "researched". By contrast, in lieu of an outsider pointing at plants and asking questions, the team focused their efforts on learning from one another that which is still remembered. The learners were present when identifying plants, learning their Taruma names, uses, and ways of identifying them, but also repeated the names for the recordings, making the learning process explicit. In one, the method was designed to activate the passive knowledge of the speakers and share knowledge with the learners and off-site team. The speaker-learner pairs also offered the speakers a real audience, which increased the speakers' involvement, as vitalizing the language was their main goal.

The effects are difficult to evaluate in the short term. A glimpse thereof can be caught, however, from the on-site team's feedback. In the evaluation, Vincent explained that "[the off-site team] awakened us to speak our language", "the names, the walk, and the whole exercise, right away I remembered my mother and the time she used to spend with us", which speaks to how the workflow helped refresh his language skills, knowledge, even memories. Irene, the more fluent speaker, added that "Vincent did not know certain names, so Nita came to me and I was able to tell her", which testifies to the knowledge exchange among the team. Speaking of the learners' experience, Elizabeth stressed that "[the project] helped our brains to open up more to Wapichan, Taruma, and even English". The learners also noted that they learned new plant names and uses and that in the future they wish "not only to talk in Taruma but [also] to write it". This also applied to Wapichan; even Konaukii, a Wapichan woman, noted that she learned new Wapichan plant names and gained experience in translating.

Our setup also limited the risk of sharing culturally sensitive knowledge with outsiders and entailed the creation of multimedia data. Since the vouchers and videos with time-aligned photographs, including Indigenous plant names in their orthographic form, and their botanical names—information that the on-site team was interested in—were deposited in Maruranau in a format compatible with the oral culture of its inhabitants, we can speak of exchanging knowledge in the opposite direction as well. By studying the recordings, we are also able to monitor the learning process. The learners initially imposed Wapichan rules on Taruma, e.g., dropping the word-final vowels of Taruma words, which the linguist could alert them to. By pointing out the information lost in translation, they could help improve the team's translations skills. The on-site team also learned how to make good quality photographs and recordings, and subsequently set out to record longer texts. They furthermore improved their skills regarding selecting the right photo and audio files, as well as storing and transferring these. Acquiring such skills requires little training as WhatsApp is designed in a user-friendly way and has a self-explanatory interface. Even the local coordinator was surprised to learn how useful WhatsApp can be in research.

Assessment of logistic

Finally, we discuss logistics: human resources, digital tools, budget, and time management. Given the complexities of working with an Indigenous community and the remote nature of research, such remote collaborations cannot take off the ground without prior contacts with the community. While an on-site coordinator managing the payments, equipment, logistics, and functioning as a local ombudsman is indispensable, no prior familiarity with remote research, nor with smartphones, is required to carry out such research. Relying on photographs and voice messages, the method in fact supports communities with oral cultures where literacy rates are low. The off-site team must be prepared to work with several types of software, e.g., Python, ELAN, Lameta. While a linguist can help with the representation of Indigenous words and detailed translations, as long as the recorded names and uses are stored as primary data in a publicly accessible archive, such work can in principle be postponed. A project that sets out to document forest species will likely need a tree climber and additional voucher collection.

The popularity of smartphones and their ability to record offline make them well-suited for such research. The data can be shared using any application with a messaging function, e.g., WhatsApp or Telegram. Most such applications allow for intimate multilateral interactions and permit sharing photo, audio, video, and text data. The team has to make an informed choice, however, as they vary in their functions, security, and user-friendliness (Douedari *et al.* 2021). Facebook Messenger, for instance, limits the length of voice messages to a minute, making it unsuited for recording longer texts. Most applications also reduce the quality of the data. Many smartphones can encode GPS coordinates of the location where the picture was taken, which can be used to create distribution maps or locate the plants later to create physical vouchers. WhatsApp, however, strips the photographs off such data (an

unencrypted transfer system or Google Drive can solve the issue, though this may compromise the security of the data). To record video, the phone must be able to create HD videos, which increases its cost.

While saving money is a secondary concern, funds for fieldwork in conflict-affected areas or under travel bans can be challenging to find. Therefore, remote methods, cost efficient as they are, can allow researchers to carry on with their work. In our case, the method removed the cost of travel, accommodation, and permits to collect and export voucher material. Expenses that fieldwork does not incur include the costs of transferring and collecting money at the nearest bank, the local coordinator's salary, and the price of a smartphone. Compensation for the on-site team was established at $5 per hour per person, the equivalent of a local primary school teacher wage. This language documentation standard was a good fit for the project, as some plants required significant time to locate, and was deemed a great benefit by the on-site team. The total budget ($1590) amounts to less than the cost of one person traveling from Europe to Toronaawa and, transfer costs aside, can be seen as an investment in the community, particularly valuable during the pandemic when income is limited.

Remote research also gives the team more flexibility in planning the work into their daily schedules than research based on a short intensive fieldwork. Vincent and Irene, for example, could plan their work rather easily into their farming schedule. The rest of the on-site team, who have a paid job, however, found it difficult to manage their jobs and the project, a problem that would have become more serious during a field visit. The team also had more time to think about what they wanted to record, which given that the speakers do not use Taruma on a daily basis, added to the quality of the documentation. Finally, while the process of obtaining permits to export plants from Guyana is incompatible with the timeframe of student projects (1-2 months of fieldwork for a MSc student), even planning a visit to the area can be complicated. The Rupununi, its major river, floods in the rainy season making entering and working in Toronaawa difficult. What is worse, due to the current climate crisis the seasons are difficult to predict. Indeed, we canceled a follow-up visit in 2022, as the rains started two months earlier than usual. Remote research is more resilient to such unexpected problems.

Conclusions

This modest contribution to the ethnobotany of Guyana took up the challenge of bridging the gap between the ambitions of the two teams (collaboration), that between their respective locations (remoteness), and that between the practice of the two academic disciplines involved (empiricism). On the whole, the method was a success. It allowed the Indigenous participants to activate their passive knowledge of their language and plants and share it with their relatives and interested Wapichan people, as well as audiovisual output that was both compatible with the oral culture of the community and stimulated the creation of digital Indigenous-language content. While we experienced problems with identifying taxa growing in more densely vegetated landscapes, translating plant uses proffered in Indigenous languages, and communicating over unstable internet connection, the remote method allowed the researchers from the Netherlands and the US to identify many of the recorded taxa and study their names and uses. The remote method, which favored the creation of primary audiovisual data, also helped the team bridge the gap between linguistics and botany, two disciplines at the core of ethnobotany. The audiovisual documentation of Indigenous plant-related knowledge produced high-quality vouchers that meet the visual standards of botany (except for forest trees and lianas) and a corpus of primary audio data of Indigenous plant names and their uses that meets the requirements of linguistics and incrementally enhance the quality of the documentation. With both datasets stored locally and in a professional archive, the documentation also has the potential to stimulate both the Indigenous community and researchers in their further plant and language-related work. We see remote research solutions not as replacements for in-person collaborations, but as valid and dynamically evolving research methods in their own right. We hope that our insights inspire ethnobotanists to use smartphones as research tools, not only during periods of restricted physical access, but also to extend research beyond the fleeting field visits and to complement traditional data collection methods, elevating the empirical standards of ethnobotany.

Declarations

Ethics approval and consent to participate: Prior informed consent for data collection was obtained orally by team member AG with on-site team members EL, NL, IS and VL and was later recorded by KR when visiting Maruranau (Guyana) after the data collection for this study had finished. We recorded bilingual consent in Wapichan and English as audio files and have deposited these in the Endangered Languages Archive (see https://www.elararchive.org/uncategorized/SO_f53d1792-26be-4ea7-9e22-fc8ba33bc512/). An ethics committee approval was not needed for this study.

Consent for publication: Consent for publication was recorded by KR when visiting Maruranau, see https://www.elararchive.org/uncategorized/SO_f53d1792-26be-4ea7-9e22-fc8ba33bc512/
Availability of data and materials: All datasets have been deposited in the public repository of the Endangered Languages Archive, see: https://www.elararchive.org/?s=taruma&hh_cmis_filter=imdi.language/Taruma
Competing interests: The authors declare that they have no competing interests.
Funding: This project was funded in part by the Alberta Mennega Fund and the van Eeden Fund.
Authors' Contributions: In collaboration with RB and KR, AH developed the remote methodology tested in this project. RB identified the plants in the photos and uploaded the audio to ELAN. AG coordinated between the *in-situ* researchers and the *ex-situ* researchers from Guyana. AS transcribed the Taruma and Wapichan words and phrases recorded. EL and NL photographed the plants, recorded the words/phrases in Wapichan and Taruma from IS and VL, and sent this data to the *ex-situ* researchers. KG coordinated data collection with EL and NL, and ensured the data was sent via WhatsApp correctly. IS and VL identified the plants in Taruma and Wapichan and described the plants in Taruma in the recordings by EL and NL. KR was the project leader. With AG he coordinated the project and wrote the majority of this manuscript. TA was the thesis supervisor for AH and RB and helped with the plant identifications

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Appendix 1. Python script used to concatenate WhatsApp voice recordings into longer files, convert them from MP4 to WAV format, and create corresponding ELAN files. The script is adapted from scripts written by Kelsey Neeley (https://github.com/kcneely - accessed June 2021).

The script below takes a set of MP4 audio files as input, e.g., voice recordings downloaded from WhatsApp, and uses the open-source software ffmpeg.exe (https://ffmpeg.org) to convert them into a single concatenated WAV file. Additionally, the script creates a corresponding ELAN file, with a tier identifying each of the original MP4 files by their original file names. The ELAN file is used for further annotation of the WAV file. The script differs from the process-session.py and create-eaf.py scripts by Neely in that it uses the original file names of the MP4 files to identify each original segments, which allows the users to keep track of the original files within the concatenated file. This is particularly useful if there are other data, e.g., photographs with names corresponding to the original MP4 files, related to the audio, which then can be time-aligned with the relevant timestamps.

Step 1: install python.exe and ffmpeg.exe
Step 2: back-up the MP4 audio files in case something goes wrong
Step 2: create a folder including the script, ffmpeg.exe, and the MP4 files to be used
Step 3: double click the script to run it: success.wav and success.eaf files will appear in the folder Step 4: check if the success.wav works
Step 5. open success.eaf in ELAN and link the success.wav to it to see if it works
Step 6: rename success.wav and success.eaf to match your project's file naming convention

```
********************************************************************************
import
glob
import
os
from datetime import datetime
import subprocess
import wave
import
contextlib

##call ffmpeg to reencode individual mp4 files to wav files## files =
glob.glob('*.mp4')
for file in files:
name = ''.join(file.split('.')[:-1])
output = '{}.wav'.format(name)
reencode = 'ffmpeg -i {} {}'.format(file, output) subprocess.call(reencode)

##create file listing##
names = [os.path.basename(x) for x in glob.glob('*.wav')] names =
map(lambda x: 'file \'' + x + '\'\n', names)
with open('output.txt', "w") as a:
a.writelines(names)

##call ffmpeg to concatenate multiple wav to single wav## filelist =
'output.txt'
output = 'Success.wav'
concatenate = 'ffmpeg -f concat -safe 0 -i {} {}'.format(filelist, output) subprocess.call(concatenate)

#Set counters for time slot IDs and annotation IDs in .eaf file
annotation_index = 1
time_index = 2
time_value = 0

#Open .eaf (XML) file and define sections with
open('Success.eaf', "w") as a:
header = '<?xml version="1.0" encoding="UTF-8"?>' + '\n' + '<ANNOTATION_DOCUMENT AUTHOR=""
DATE="" FORMAT="3.0" VERSION="3.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://www.mpi.nl/tools/elan/EAFv3.0.xsd">' + '\n' + '\t' + '<HEADER
MEDIA_FILE="" TIME_UNITS="milliseconds">' + '\n' + '\t \t' + '<MEDIA_DESCRIPTOR
MEDIA_URL="file:///[FilePathAndName]" MIME_TYPE="audio/x- wav" RELATIVE_MEDIA_URL="./Success.wav"/>'
+ '\n' + '\t \t' + '<PROPERTY NAME="URN">urn:nl-mpi-tools-elan-eaf:8b09aae8-a8b8-4e21-8c96-
14316c8e908a</PROPERTY>' + '\n' + '\t \t' + '<PROPERTY
NAME="lastUsedAnnotationId">1</PROPERTY>' + '\n' + '\t' + '</HEADER>' + '\n' + '\t' +

'<TIME_ORDER>' + '\n' + '\t \t' + '<TIME_SLOT TIME_SLOT_ID="ts1" TIME_VALUE="0"/>'

middle = '\t' + '</TIME_ORDER>' + '\n' + '\t' + '<TIER LINGUISTIC_TYPE_REF="Text"
TIER_ID="Original_Time_Stamps">' + '\n'

footer = '\t' + '</TIER>' + '\n' + '\t' + '<LINGUISTIC_TYPE GRAPHIC_REFERENCES="false"
LINGUISTIC_TYPE_ID="Text" TIME_ALIGNABLE="true"/>' + '\n' + '</ANNOTATION_DOCUMENT>'

#Write XML header and the opening tags for the time order portion of the .eaf file a.write(header)
a.write('\n')
```

```
#Loop through files to get clip durations, convert times to ms, and write time slot IDs with time values
files = glob.glob('*.wav') for file
in files:
file_name = os.path.basename(file) try:
with contextlib.closing(wave.open(file_name,'r')) as f: frames =
f.getnframes()
rate = f.getframerate() duration = frames /
float(rate) duration = str(duration) duration
= float(duration)
duration = int(duration * 1000) time_value = time_value
+ duration
a.write('\t \t' + '<TIME_SLOT TIME_SLOT_ID="ts{}" TIME_VALUE="{}"/>'.format(time_index, time_value) + '\n')
time_index = time_index + 1 except:
pass

#Write closing tags for time order portion and opening tags for annotation portion of .eaf file a.write(middle)

#Reset time slot ID to 1 and loop through files to generate annotations identical to the file name of the
corresponding .wav clips
time_index = 1 for
file in files:
file_name = os.path.basename(file[:len(file)-4]) try:
annotation_value = file_name
a.write('\t \t' + '<ANNOTATION>' + '\n' + '\t \t \t' + '<ALIGNABLE_ANNOTATION ANNOTATION_ID="{}"
TIME_SLOT_REF1="ts{}"

TIME_SLOT_REF2="ts{}">'.format(annotation_index, time_index, time_index + 1) + '\n' + '\t \t
\t \t'+ '<ANNOTATION_VALUE>{}</ANNOTATION_VALUE>'.format(annotation_value) + '\n' + '\t \t \t' +
'</ALIGNABLE_ANNOTATION>' + '\n' + '\t \t' + '</ANNOTATION>' + '\n')
annotation_index = annotation_index + 1 time_index =
time_index + 1
    except:
        pass

#Write closing tags of annotation portion and footer of .eaf file
a.write(footer)

##delete all generated .wav files in the folder except for the concatenated "master" file (assumes the file names
are longer than 7 characters)##
files = glob.glob('*.wav') for
file in files:
name = os.path.basename(file) if
len(name)>15:
os.remove(file)

##delete all generated .txt files in the folder ## files =
glob.glob('*.txt')
for file in files:
name = os.path.basename(file)
os.remove(name)
```

Appendix 2. Guidelines for the conversations about the remote collaboration sent to the on- site team, and the responses of the off-site team, written down by Adrian Gomes in English (the original conversations were in Wapichana and English).

Hello everyone,
We hope that everyone is doing good in Guyana. As you know on our side we are working hard on studying all the recordings you sent us and all the recordings we created when we visited you. At this point, we would like to publish an article in a scientific journal about how we worked together using the phone and WhatsApp to communicate. You have made this collaboration possible and developed it with us. We would like all of us to be the authors of this article, which we plan to publish in a journal that other plant experts read. Because of this there are two things we want to ask you:

The first question is whether everyone would like to be included as authors in the article? If yes, please send us a list of all the name we need to include. We will send you the final version of the article for you approval before submitting it.

Second, in order to write the article, we want to ask you your opinions about how this project went—what you liked about it and what you didn't like—so that in the future we can do it better and so that others can learn from us. To make this easier, we prepared a short list of questions. Please treat those questions as guidelines and feel free to raise any other topics, issues, problems, and questions. We understand also that it will take some time to ask about everybody's opinion and to type it up on the computer. Please keep track of this time, since we will reimburse it from the project and remember these questions are only about our work before the trip to Guyana: the work we have done through the phone.

1. **Please tell us how your work looked like: who worked with whom and who did what?**
Vincent: Nita asked me questions. I told her the names of plants in Wapichan and Taruma.

Elizabeth: I asked questions in Wapishana and Irene answered in Wapishana and in Taruma. I worked with aunt Irene mostly. We talked about history of the Taruma. We also talked about types of cassava. Other times we talked about plants. We also talked about costumes e.g., head bands, bangles, drapes.

Nita: I asked my dad Vincent questions and he answered in Wapishana and in Taruma. We talked about plants in the farm, in the forest, around the house. We talked about the tools we used for cassava work.

Irene: I worked with Vincent and Elizabeth. Before, Adrian talked to us about the work in general. I answered their questions. I told my mind about it.

Adrian: I worked with everyone in the team. I first briefed everyone about the project. I went to the Uncle Vincent's place to meet Elizabeth and Nita first. Then I arranged to meet Uncle Vincent and Aunt Irene to tell them about the project in the presence of Nita and Elizabeth. Sometimes Konaukii accompanied me to meet with everyone at the Taruma's place or we just meet Elizabeth and Nita on different aspects of the project as it developed. I communicated with Konrad, Robin and Anne about what's happening. Further, I explained the steps that need to be taken whenever things need to be done. This type of contact was maintained throughout.

Konaukii: I worked with everyone. My main job was editing and sending the Data that was collected via internet. I also helped in recording the members, speaking in Taruma and Wapichan. At one point I even showed them how to use the phone to record voice notes.

2. **What did you like most about the project and why?**
Vincent: All I like. The names, the walk and the whole exercise. Right away, I remember my mother and the time she used to spend with us.

Elizabeth: Every aspect of it. This is because I found myself learning too.

Nita: I like all aspects of the project, especially about the plants, their names, their uses. I wish to learn more about plants.

Adrian: I liked the collaboration, speaking to everyone in the team. I liked the way that everyone was cooperative and supportive as we sought to do was required. I also liked the instructions sent by Robin and Anne with example pictures. One can follow these models to have a standard in presenting work.

Konaukii: I liked how co-operative the team was and I enjoyed interacting with them. Everyone was eager to work with each other.

3. **What would you like to change about the project and why?**
Vincent: Good. No change needed. Let us continue the same way.

Irene: What names are said in Wapishana, I told in Taruma. I like the Taruma language.

Elizabeth: Make sentences in Taruma. We can be able to make short stories about ourselves in Taruma; to enable us not only to talk in Taruma but to write it.

Nita: To write more in Taruma. To be able to make stories in Taruma.

Adrian: I think there should be a short practice or training session each time a new set of tasks was set. This could have been overseen by me or Konaukii in order to avoid things to be redone.

4. **What did you find most difficult in this project?**
Irene: Sometimes, I forgot. What I know I tell.

Vincent: There wasn't anything hard really. I liked the way we worked. Nita: Learning Taruma. In writing and spelling the words.

Elizabeth: Learning to speak in Taruma. Searching for certain plants is difficult. Takes a lot of patience.

Adrian: I think it was getting things done in a timely manner. First the pictures need to be checked and set before they are sent.

Konaukii: Sending of Data was most difficult here because there is no internet in the village so I had to go to neighbouring villages to send the Data. In addition, a lot of time was lost because of slow internet, not all items could be sent all at once.

5. **Was it easy for you to plan your work and fit it into your daily life, and why?**
Vincent: We do not work every day. So, that allows me to put work into my farm for days at a time. It allows me to plan my work ahead.

Irene: I did not say anything about it being hard. I try to cooperate because it is work too.

Elizabeth: No, it was not easy. There was often a conflict with project work and my own work at home. When I think of the activities of the project, I had some other work to do such as house work and finding time to help my son with his school work. I also think a lot about how to do the translations in English.

Nita: No, I have to first ask my dad about information before I record. Sometimes, my dad would forget and would not remember. When he got sick, work was delayed. We had wait until he recovered. So, in this way, we could not keep a steady schedule.

Adrian: Sometimes, this work did clash with my own local work. So, it was a challenge to fit it into my normal schedule.

Konaukii: Sometimes, I find it a bit challenging to fit into my teaching work but I like a challenge, so I made time to

complete the work.

6. **How did you benefit from the project (e.g., Did you learn something new)?**
Vincent: I was able to earn a bit of money for my work. It was good like that. Nothing new really.

Irene: I received some money for my work. From Nita, I learnt that Vincent did not know a certain names. So, Nita came to me to hear from me and I was able to tell her. Nita seemed to work faster than Elizabeth.

Elizabeth: Yes. More about names of plants or new words in Taruma. I learn to write in Taruma. I also learn more about Wapishana from Aunt Irene. Some words in Wapishana I did not know, I learnt then.

Nita: Yes. I learnt something new. I learnt more about names of plants in Taruma. Names I did not know, I got to know. I learn the letter sounds in Wapishana and Taruma.

Adrian: I learnt that the smart phone could be used as tool to do this kind of research although the pictures may not be of high quality as they are sent by WhatsApp. I benefited from developing more networks with young researchers and that this leads to meeting new and pleasant people to work with. So, in the end they actually came to visit and work with us. I was able to introduce them to the villagers.

Konaukii: This is my first time working on a project like this so I learnt many things. Learning new words in Wapishana especially plants, and having an experience in translation of the two languages: Wapishana and Taruma.

7. ***Did you like sending photos and voice messages via WhatsApp and why?*** Vincent: Yes. It was okay. Also, the recordings of messages were good. Elizabeth: Yes. In this way, other participants were able to hear our voices.

Nita: Yes. They now know too that it is the first time we are learning Taruma in this way. Irene: Yes, it is okay.

Adrian: It is a first for me. I like the fact that the researchers from abroad appreciated them. The pictures looked great in the document that was being prepared.

Konaukii: Yes, it was okay.

8. **Is the phone useful to you after the project?**
Vincent: The phone is of use to us.

Irene: They (Nita and El;izabeth) know how to use it. So, any messages to me will come through the phone through Elizabeth or Nita. If I have any message, I will be able to send it too.

Elizabeth: Yes. The project helped our brains to open up more about Wapishana, Taruma and even English.

Nita: Yes. You learn to record and practice. We learnt how to use the voice recorder. Adrian: I think Nita and Elizabeth are using it for their own communication for now.

9. **Were the instructions that we sent to you clear?**
Vincent: The instructions were clear.

Nita: Yes. I tried to follow the instructions.

Elizabeth: Clear. I understand. Voices were clear. I played the instructions over and over to understand.

Irene: Yes, they also shared what was needed. Adrian: The instructions at first were not very clear.

Afterwards, they were much clearer with examples of how some activities should be done. Konaukii: Yes it was.

10. **What problems with communication did you encounter with others in Maruranau?**
Vincent: Communication was good to me throughout.

Irene: Not really. Others communicated well with me. I knew what was happening.

Nita: Other CSOs are saying that Nita has another bossman; she is getting double pay. It is possible to change her. But I am still working as a CSO with the Nursery school. Nobody like the Toshao told me to stop work.

Elizabeth: Nobody told me anything like what was told to Nita. There is nothing about what I am doing to be envious about. Other people are calling me Taruma waba.

Adrian: Sometimes, we do not have mobile phone signal to communicate immediately. So, I find that sometimes I had to travel to the Taruma's place on motorcycle to communicate face to face with them. Sometimes, I do not find them at home. So, that delays communication sometimes.

Konaukii: As mentioned already, delayed communication was a problem since there was no continuous phone signal.

11. **What problems with communication did you encounter with us in the Netherlands?**
Vincent: Also good communication between us and you over there. Irene: Yes. Messages from you reached us.

Elizabeth: No problem. Except that we could not talk with you because of the problem we have with the WIFI in Maruranau.

Nita: No problem. I went to Awarewaunau to chat with Konrad on line, but he was not on line.

Adrian: The only major problem was that our WIFI in the village malfunctioned since last year February or March. Afterwards, I had to motorcycle 5 miles away to Shea or 10 miles away to Awarewaunau to send messages or receive messages. This is still the problem. I understand there is a major problem with this. The government sent a message that they are going to send an engineer to fix the problem next month, April.

Konaukii: The only problem was no Internet in the Village and that also contributed to delayed communication from the Researchers.

12. **Were the problems you encountered adequately addressed during the project?**
Vincent: No problem really. Irene: No problems really.

Elizabeth: Problem still the same with the WIFI. Nita: Problem still the same the WIFI.

Adrian: I think so.

Konaukii: Yes it was.

13. **Was it difficult to communicate with people you had not met before?**
Irene: No difficulty. I felt confident in communicating because I worked with others before. I felt no fear.
Vincent: I felt good; confident.

Elizabeth: The first time we were nervous but after some more contacts it was easier. Sometimes I cannot respond very quickly, not accustomed to fast speaking.

Nita: Yes. It was hard. I felt afraid. But afterwards it was okay. Adrian: No.

Konaukii: No

14. **Were there any parts of the plants you felt should have been photographed?**
Vincent: All good. Most parts that could be photographed were done.

Irene: The pictures were all clear. Not sure; almost all parts of the plants were taken. Elizabeth Louis: There are still some plants parts we did not tell.

Nita: We photographed almost all that was possible. Only, about the pumpkin. We couldn't split the pumpkin because pumpkin season was done.

Adrian: I think most of the plants parts that could be taken were done. Konaukii: I think most parts of the plants were taken.

15. **Other comments**
Vincent: I felt good working with Konrad, Robin, Anne, Adrian and Kponaukii. We felt that they have awakened us to speak our language. Adrian told me that Konrad was to come next week for another trip but cancelled it because of impending rains. It is true. Rains seem to be on the verge of the season already.