Chapter 11
Contributions to Socio-environmental Research through Participatory GIS in Archaeology

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Abstract This chapter reviews the contributions of an engaged archaeological framework to past and present research about human-environmental relationships in Latin America. We argue that archaeology can play an expanded role in advancing our understanding of long-term socio-environmental systems by promoting greater integration between scientific research and broader societal needs and local spatial knowledge within the context of sustainability. We further suggest that participatory approaches can bridge some of the conceptual divides that separate archaeologists and anthropologists from Indigenous and local communities and contribute to the decolonization of the discipline. Specifically, the aim is to show how participatory mapping and participatory geographic information systems can be suitable tools to engage archaeological studies of human-environment interactions from an integrative research perspective.

Keywords Landscapes · Human–environment interactions · Remote sensing and GIS · Participatory mapping · Local spatial knowledge · Traditional ecological knowledge

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1 Introduction

A major topic of contemporary archaeological inquiry is the examination of the relationship between people and the environment (Kintigh et al. 2014). A crucial component of this research centers on a variety of spatial analytical methods (Gillings et al. 2020) that have been developed by archaeologists over the last century. Among the analytical techniques that archaeologists utilize, remote sensing (RS) has become increasingly important. Yet, as stated in the introduction of this volume, a challenge that RS studies face is its integration with the social sciences and humanities. In this sense, archaeology has contributed to narrowing this gap due to its long relationship with RS and spatial analysis (Clarke 1977; Hodder and Orton 1976) in addition to common research questions that focus on long-term perspectives on human-environment relationships. This characteristic of archaeology has helped connect social, historical, and ecological perspectives, providing new insights into socio-environmental system dynamics (Van der Lleeuw and Redman 2002).

Latin American archaeology first incorporated RS into its practice between the 1930s and1960s. Aerial photography was used in some of the first studies of pre-Hispanic settlement patterns, a type of spatial analysis that examines how archaeological sites are distributed on the landscape (Willey 1953; González 1957; Kosok 1965; Denevan 1993). In the 1990s, archaeological studies adopted satellite imagery and geographic information systems (GIS) as fundamental tools for mapping and sophisticated spatial analysis (Grau Mira 2006; Llobera 2007; Kosiba and Bauer 2013). More recently, the introduction of unmanned aerial vehicles (UAVs), light detection and ranging (LiDAR) technologies, and photogrammetry for surveying large archaeological areas and the production of high-resolution digital elevation models led to a revolution in the way spatial and socio-environmental studies were conducted (Chase et al. 2017; Canuto et al. 2018; Greco 2018; Iriarte et al. 2020; VanValkenburgh et al. 2020).

Contemporary archaeology goes well beyond the reconstruction of past societies for the sole purpose of increasing historical and anthropological knowledge. The data generated by archaeology coupled with climate proxies, local spatial knowledge (LSK), and traditional ecological knowledge (TEK), provide a long-term multi-scalar understanding of human-environment interactions (c.f. Sandweiss and Kelley 2012, Nesbitt 2016, 2020, Caramanica et al. 2020, Haldon et al. 2020, Kohler and Rockman 2020, Pauketat 2020). For example, satellite imagery and GIS are being used to estimate the extent of anthropogenic soils known as Amazonian Dark Earths (ADEs) or *terras pretas* (Heckenberger et al. 2007, 2008; Palace et al. 2017). Similarly, LiDAR has demonstrated the scale of settlement in Mesoamerica and parts of Amazonia, suggesting exceptionally large, dense populations prior to European contact (Canuto et al. 2018; Iriarte et al. 2020). These technologies coupled with LSK and TEK can determine the impact that current Indigenous activities, including cultivation practices, have on these soils and the surrounding environment (Schmidt 2013).

This research is not undertaken in a vacuum and has real implications for Indigenous descendent communities. With respect to past and present

human-environment dynamics, there is an increased awareness of the role archaeological research plays in relation to the needs and demands of local stakeholders around the world (Colwell-Chanthaphonh and Ferguson 2008; Atalay 2012; Douglass et al. 2019; Gupta et al. 2020), including most countries in Latin America (Duin et al. 2014; McAnany and Rowe 2015; Álvarez Larrain et al. 2019; Herrera Wassilowsky and Curet 2019). This awareness of local demands has reoriented archaeological investigation to create projects in which knowledge is exchanged and shared. In this sense, engaged archaeology is contributing to an increased understanding of the adaptability and resilience of communities, using the past for better planning of the future, improvement of local ways of life, and promoting environmental justice (McIntosh et al. 1999; Heckenberger 2014; Caramanica et al. 2020; Douglass and Cooper 2020; Fisher 2020; Heckenberger 2020; Kohler and Rockman 2020; Rick and Sandweiss 2020; Rockman and Hritz 2020).

Local and Indigenous people's engagement with archaeological studies is not new; the record of LSK and TEK as it relates to the study of past environments', especially in the tropical lowlands of Central America, Andes, and Amazonia, is very robust (Erickson 1998; Kendall 2005; Gnecco and Ayala Rocabado 2010; Schmidt 2013; McAnany and Rowe 2015). Local communities are claiming archaeological landscapes and objects as part of their ancestral cultural heritage and vital resources not only for territorial protection, but for achieving a good way of living. We argue that archaeology can play an expanded role in advancing our understanding of long-term human-environmental systems by promoting greater integration between scientific research and broader societal needs within the context of sustainability (Fisher 2020). The aim of this chapter is to show how participatory mapping (PM) and participatory geographic information systems (PGIS) can be suitable tools to engage archaeological studies of human–environment interactions from an integrative research perspective.

In the following section, we discuss the trajectory of PGIS practice in the mapping of Latin American landscapes and territories that established a precedent for the use of PGIS in archaeological research. We review current PGIS applications in archaeology and some relevant methodological approaches. Finally, we discuss the opportunities and limitations of PGIS to address issues in human-environment dynamics in Latin America, offering some reflections about new epistemological considerations on the application of geospatial technologies.

2 PGIS and Archaeology in Latin America

2.1 Trajectory of the Practice

PGIS emerged 50 years ago in land claim cases of Indigenous peoples in North America. The primary purpose of these mapping efforts was the protection of ancestral lands and recognition of local communities' decision making in resource

management in the face of commercial development projects (Freeman 1976; Brody 1988; Tobias 2000; Flavelle 2002; Chapin et al. 2005; Candler et al. 2006). Today, PGIS incorporates practices of PM with simple procedures such as sketch or mental maps, to the use of modern spatial information technologies including RS, GIS, UAVs, global positioning systems (GPS), 3D Projection-Augmented Landscape Models (3DPALM), and open access web platforms and software (Abbot et al. 1998; Corbett and Keller 2006; Sieber 2006). In many cases, PGIS is used as a spatial database and a political tool to represent LSK and TEK within conventional spatial information formats, providing legitimacy to local claims (Abbot et al. 1998; Dunn 2007; Corbett 2009; McCall and Dunn 2012; McCall 2014).

In Latin America, PGIS was more recently introduced and is closely connected with Participatory-Action (PA) research approaches (Fals Borda 1999), in which Indigenous and rural communities affected by socio-environmental problems actively participate in all steps of the research process, including planning and decision-making, which in turn generate opportunities for social improvement. These projects have been undertaken mainly by geographers and anthropologists in cooperation with conservation activists and non-governmental organizations (NGOs).

Although diverse applications of PGIS in Latin America exist (e.g., in urban planning, public health, hazard management, monitoring infringements, among others) (Risler and Ares 2013; McCall 2014), we focus on emerging mapping efforts led by Indigenous, descendant, and traditional communities directed toward territorial protection, including the preservation of their environmental and cultural heritage. These PGIS applications have a variety of goals, which include people's desire to: (1) map ancestral lands; (2) inform territory/land claims; (3) record traditional uses of territories; (3) manage natural resources and contribute to biodiversity conservation; (4) preserve Indigenous cultural resources and heritage; and (5) support land-use planning (Knapp and Herlihy 2002; Herlihy and Knapp 2003; Chapin et al. 2005; Stocks 2005; McCall 2014; Kelly et al. 2017; Álvarez Larrain and McCall 2020; Sletto et al. 2020). An extensive review of the literature (Álvarez Larrain and McCall 2019a) and recent compilations resulting from various PM conferences in Latin America (Sletto 2011; Salamanca and Espina 2012; Sletto et al. 2020), show that the practice of PGIS related to environmental and territorial protection has become widespread in the region since the 1990s. A detailed review of this extensive work is beyond the scope of this chapter, but we highlight here it's contribution to socio-environmental research and management.

Latin America has become the next predatory frontier of the globalized neoliberal world. As McCall (2014) states, the people who inhabit these lands face increasing external pressures on their territories derived from farmland and pastureland expansion; accelerated exploitation of minerals, privatization of drinking water, and petroleum production for external markets; illegal deforestation; road development, real estate business growth, and hydroelectric dam development. In the past, PGIS projects in the region were intimately related to the need to secure land tenure and natural resources by communities inhabiting the tropical lowlands in countries such as Brazil, Colombia, Ecuador, Honduras, Nicaragua, and Panama, and protecting

their territories from extractivism and outsider encroachment (Offen 2009). As Stock (2003: 345) notes, "For us, land is a factor of production, a commodity on the market. It can be bought, sold and accumulated"; but as McCall (2014) claims, local and Indigenous communities are heavily dependent on the land and its resources for cultural survival. Losing their lands is tantamount to losing their health and socio-environmental sustainability, along with their livelihoods, cultures, and identities. Currently, the remaining stands of tropical rain forest are disappearing at alarming rates due to the pressure of loggers, cattle ranchers, and entrepreneurs involved in the extraction of natural resources as part of the ongoing integration of remote areas into the global economy (e.g., Plotkin 2020).

In the late 1980s, environmentalists were challenged to shift their focus on preserving flora and fauna in human-excluded protected areas, and align with the "sustainable development" paradigm (Ruggerio 2021). As it became more apparent that the most biodiverse and healthiest ecosystems often coincide with the home of Indigenous peoples, the international conservation community began to view participatory management strategies as key elements to the conservation of the forested lowlands (Chapin et al. 2005; Stocks 2005; Kelly et al. 2010; Ramirez-Gomez et al. 2013; Sletto et al. 2013). A precursor of the idea that land use mapping by Indigenous people could bolster land tenure claims and biodiversity protection was a 1992 map of Central America and Southern Mexico produced by the anthropologist Mac Chapin showing the connection between Indigenous lands and the last remaining forest in the region (Chapin and Threlkeld 2001, 2008). Since then, a new wave of PM projects of Indigenous lands emerged to better understand Indigenous land use and integrate the knowledge, practices, and beliefs of these communities into socio-environmental research and conservation planning (TMCC 1997; IBC and Chase Smith 2012; Cerra 2014; Nenquimo 2018; ACT 2019). Climate change and the global ecological crisis have taken this partnership even further. For example, scientific studies have established that Indigenous reserves in the Brazilian Amazon have been most effective at avoiding deforestation, and that forest cover and carbon stocks are best maintained by collective long-term use-rights management systems (Duin 2018). In Central America, over 200 protected areas were established by 1990 and, virtually all the largest ones are home to substantial Indigenous populations (Smith 2008: 86). In some cases, PGIS projects have contributed to Indigenous self-determination by assisting communities obtain legal land tenure and encouraging concrete involvement in planning and resource management. Securing legal protection for their homelands and resources is perhaps, the most fundamental challenge Indigenous peoples face in preserving their way of life (Denniston 1994), but achieving land ownership has not necessarily guaranteed the conservation of the ecosystems that they rely on. For example, the socio-environmental mapping carried out in Peru by the *Instituto del Bien Común* with the Yánesha peoples of the Amazon showed that mining and forestry concessions were granted, and protected areas created by the state in previously recognized Indigenous territories (Smith et al. 2003; IBC and Smith 2012).

PGIS projects undertaken in other South American countries have focused on recovering ancestral lands lost by the configuration of national territories, as is the

case with the Diaguita and Mapuche communities of Chile and Argentina (Cerra 2011; Arias 2012; Hirt 2012; Arenas 2013; Cerra 2014; Melin Pehuen et al. 2019). However, as analyzed by Cerra (2014), although the demarcation of territorial borders can be recognized by the states, the complexity of territorial representations is not necessarily captured. The narratives and memories rooted in the landscapes, which provide primary support for Indigenous claims and environmental management practices, are usually not mapped in a Cartesian space.

Many Indigenous peoples and local communities have a close connection to place. One of the main purposes of PGIS has been the recording of information that documents the occupation history of their ancestral territory before the State and the non-Indigenous (and often powerful) segments of society. These landscapes are commonly in intimate relationship with natural resources and have helped depict the way of life of these populations. Indigenous communities want to emphasize the vitality of their contemporary culture, as well as their connection to the past. Teague (2011) observes that people alter the land through cultural practices and, therefore, the material characteristics of cultural landscapes are evidence of the long-standing relationship of a community with land. Such evidence is important in establishing traditional use rights that can be legally recognized. Yet, it is still necessary to reflect on what happens with the intangible, symbolic, mythological, and memory spaces that connect people to land (Basso 1996), which has an intimate relationship with environmental practices. Archaeology, as a discipline focused on the study of the past, can contribute to the creation of other kinds of historical narratives through the examination of past and present human-environmental dynamics.

2.2 Current PGIS in Archaeology and Methodological Approaches

In recent years, archaeology has reoriented its objectives and research focus. While maintaining its strengths in reconstructing the deep history of Indigenous cultural groups, it is also trying to shed itself of much of its colonial baggage. As a result, archaeologists have allocated significant efforts to create collaborative partnerships that address the interests and demands of local communities to recover their ancestral relationships with the landscape and participate in decision-making regarding the local environment and archaeological heritage.

With respect to mapping Indigenous cultural heritage, archaeological documentation has been based upon the fundamentals of Western cartography. Scholars have created decolonizing research methodologies by forming partnerships and recognizing the authority and rights of local stakeholders, including Indigenous, descendant, and local communities to manage their natural and cultural environments (e.g., Davis et al. 2021 for a case study example). Within Latin American archaeology, there is an emerging literature that discusses the application of PGIS on community-based research (Álvarez Larrain and McCall 2019a, 2019b). Broadly speaking, we

can identify two main trends within PGIS-based research: (1) the recording of archaeological evidence and TEK to account for ancestry as a strategy against extractivism and its encroachment into Indigenous lands (Heckenberger et al. 2003; Heckenberger 2004; Manasse 2008; Quesada 2009; Heckenberger 2014; Manasse and Vaqué 2014); and (2) research that incorporates LSK and multivocality in archaeological interpretations and heritage protection (Endere and Curtoni 2006; Martínez Celis 2013; Duin et al. 2015; Álvarez Larrain et al. 2019; Martin Silva et al. 2019; Álvarez Larrain et al. 2020; McAnany 2020).

One of the pioneering PGIS archaeology projects in Latin America, "The Upper Xingu Indigenous History Project" in the Xingu National Park in Brazil's Mato Grosso region, was initiated in 2001. For the Xinguano/Kuikuru people, archaeology has been a critical tool that has allowed them to defend their cultural and land resources by learning about the ancient places where they dwelled, linking oral histories to their deeper past (Heckenberger 2004). Archaeological studies based on RS and excavations have shown large, permanent, and densely distributed settlements and significant landscape modification, including *terras pretas*, widespread across large areas of the Amazon region and hidden under the forest canopy (Heckenberger 2020). Archaeologists have asserted that Pre-Columbian societies developed sophisticated systems of land-use and management and engineered landscapes creating mosaics of bio-historical diversity (Heckenberger et al. 2003; Palace et al. 2017), supporting the idea that the current Amazon tropical forest is the product of millennia of anthropogenic activities (e.g., Balée 2014; Walker 2018; Balée et al. 2020). The PGIS project developed research strategies focused on partnership and training with descendent communities whose livelihoods depend on the integrity of the Xingu socio-ecological landscapes. It can be quickly assessed from open-access satellite images that the Xingu National Park contains devastated forests along its boundaries caused by cattle ranching, soy farming, urbanization, and hydro-electric projects. The project involved satellite image analysis, GPS ground-based mapping, and GIS that incorporated ecological data and TEK, and was designed to work in conjunction with broader global environmental agendas, such as biodiversity conservation and tropical forest degradation reduction programs. More recently, this collaborative project initiated the development of a GIS dashboard that enables local communities use mobile applications to monitor who is traveling within the park, track real-time health patients, and visualize the impacts of the Covid-19 pandemic (Fig. 11.1). In countries like Argentina, with a long history of neglect and state violence against native communities, PGIS has led to a new Indigenous cartography of ancestral territories, with the goal of developing a useful legal tool for land claims cases. From this perspective, archaeological evidence constitutes an important construct of cultural identity for these communities. PGIS appeared at a time when different social actors claimed cultural and archaeological heritage, which was negatively affected by modern economic activities such as mining, real estate transactions, tourism, and commercial development embedded in neoliberal logic (Manasse 2008; Montini 2008; Quesada 2009; Manasse and Vaqué 2014).

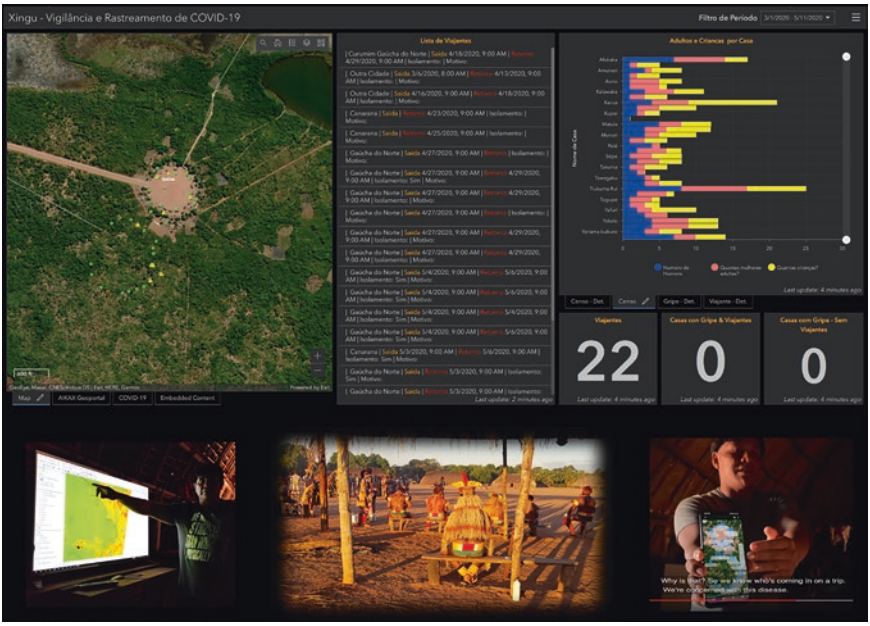

Fig. 11.1 COVID-19 dashboard of the Kuikuru people living in the Xingu National Park in Brazil's Mato Grosso region (Source: https://storymaps.arcgis.com/stories/d13c50b64ada4e53856b3d4d64a08bcb)

Working with local families in Antofalla, NW Argentina, Quesada (2009) used satellite images to identify the places where families practiced traditional economic activities, indicating the location of toponyms and places of ritual practices. The author shows the continuous use of the territory by the Indigenous community in a landscape that was depicted as empty on standard (Western) maps, which had clear geopolitical implications. During the mapping process, Quesada observed that satellite images were oriented in relation to the position of the "morning sun" or "afternoon sun" (2009: 163). In the mapping of a Diaguita community territory in Cafayate, NW Argentina, Cerra (2014) indicates that the maps were drawn according to the upslope direction of hills. Barrera Lobatón (2009) expresses this dichotomy between virtual Euclidean space vs. lived space, and the importance of the narratives in the ways of representing that experienced space. In the former, estrangement is required, in the latter that is impossible.

As Montini (2008) points out, the most visible impact of the privatization of space is the breakdown of the production system of the local populations, as is the curtailment of access to natural resources that is crucial to cultural and material life. As it can be seen in the mapping processes undertaken by the Mapuche people, the way of understanding the territory assumes an occupation dynamic that does not necessarily translate into a continuous human presence throughout the territorial space related to subsistence. There are forbidden spaces for people that have significant ancestral and ritual meaning, but are equally necessary to sustain the balance of

life in a territory (Rodriguez de Anca et al. 2013). As Smith et al. (2012: 121) state: "There are many dimensions of local Indigenous knowledge and landscapes that are difficult or impossible to include in a computer database, or that lose their meaning when taken out of context. Stories about legendary battles between mountains, the calls of birds associated with specific places, the awe that ancient archaeological sites inspire, or the tensions arising from boundary disputes are things that cannot be reduced to zeros and ones". Though the authors are referring to the Mexican context, this statement could apply to a wide range of Indigenous populations in the Americas (see for example Basso 1996; Bray 2015). In addition, territorial overlaps can be a central feature of traditional land tenure that contradicts conventional notions of private property.

Recent archaeological research within the Maya region in Guatemala also demonstrates some of the trends towards PGIS in socio-environmental studies with descendant communities. Maya archaeology has pioneered RS and satellite technology to record archaeological evidence hidden by forest cover. As noted earlier, this technology- especially LiDAR- has created a wealth of new settlement data that was not readily available through conventional surveys (Canuto et al. 2018). On the other hand, challenges about partnership building around community mapping are critically reviewed in relation to the politics of heritage, the nation state (Chase et al. 2020) and identity among Maya communities. The Guatemalan Community Mapping Project was originally conceived to represent shrines and archaeological sites. Later, community members expanded the scope of the project to include natural and cultural resources (McAnany et al. 2015; McAnany and Rowe 2015). Technical workshops on computer and field-based mapping and GPS to identify sites, and on how to display points on Google Earth, were part of the approach.

In French Guiana and Suriname, a growing number of Wayana people have begun to appreciate archaeology as a tool to describe their past and as a powerful asset to rewrite their history (Duin et al. 2014, 2015; Duin 2017, 2018). In Wayana villages, archaeologists and community members employed ecological indicators and pottery fragments together with oral history to construct a GIS model for predicting the location of archaeological sites. Wayana elders and their oral accounts provide insight into settlement patterns that are not on any historical maps. Wayana social memory indicates that many people used to live in areas along tributary rivers, which are largely depicted as vacant on official maps. In contrast, community-based research demonstrated that this region was far more densely populated. In a similar context and in relation with oral history, the Amazon Conservation Team (ACT) presents "Terrastories", a Mapbox platform application built to enable local communities to locate and map their oral storytelling traditions (Fig. 11.2). Terrastories is designed to be entirely offline-compatible, so that remote communities can access the application without needing internet connectivity (ACT 2019: 37)[7].

A recent experience with high school students in Yocavil, a Diaguita-Calchaqui territory in NW Argentina, combined aerial photography mapping, field trips, and UAV flights to register meaningful cultural sites (Álvarez Larrain et al. 2020). The aim was to approach the archaeological landscapes of Yocavil from a local spatial

Fig. 11.2 "Terrastories", a Mapbox platform application built to enable local communities to locate and map their own oral storytelling traditions about places (Source: https://terrastories.io/demo/)

knowledge viewpoint to assess the significance of archaeological sites in the history and culture of the valley, as well as in relation to the knowledge generated by archaeologists. The main activity consisted of a field trip to a location using a satellite image enlargements of the valley's southern portion. Students travelled to a pre-Hispanic town with some defense features located on a low hill near the school. Once at the top of the hill Álvarez Larrain and colleagues employed the technique of scale mapping and asked students to mark the places they knew including modern towns, archaeological sites, or other types of meaningful places on the images. A few days after the workshop, a field trip was organized with one of the students and his teacher to record a meaningful site. The researchers were surprised when they recognized that this settlement presented a clear Inka architectural pattern, which had important implications for the reconstruction of the expansion of the Inka Empire from its capital, Cuzco, Peru. Subsequently, a drone survey was carried out to make the preliminary map of the core part of the settlement by photogrammetry and obtain video footage (Fig. 11.3).

The history of the Indigenous peoples of Latin America is subject to complex internal and external socio-political processes (e.g., genocide, disease, territorial and population displacements, and confinement) that began in the late fifteenth century and endures until today. Archaeology and anthropology have operated for well over a century within these contexts (e.g., Trigger 1984; Habu et al. 2008). In recent years, archaeologists have made important strides toward decolonizing archaeology through a variety of more inclusive practices that aim at benefiting the communities with which they work. In our view, PGIS is one such approach that bridges some of the divides that separate the views of academics and those of Indigenous actors.

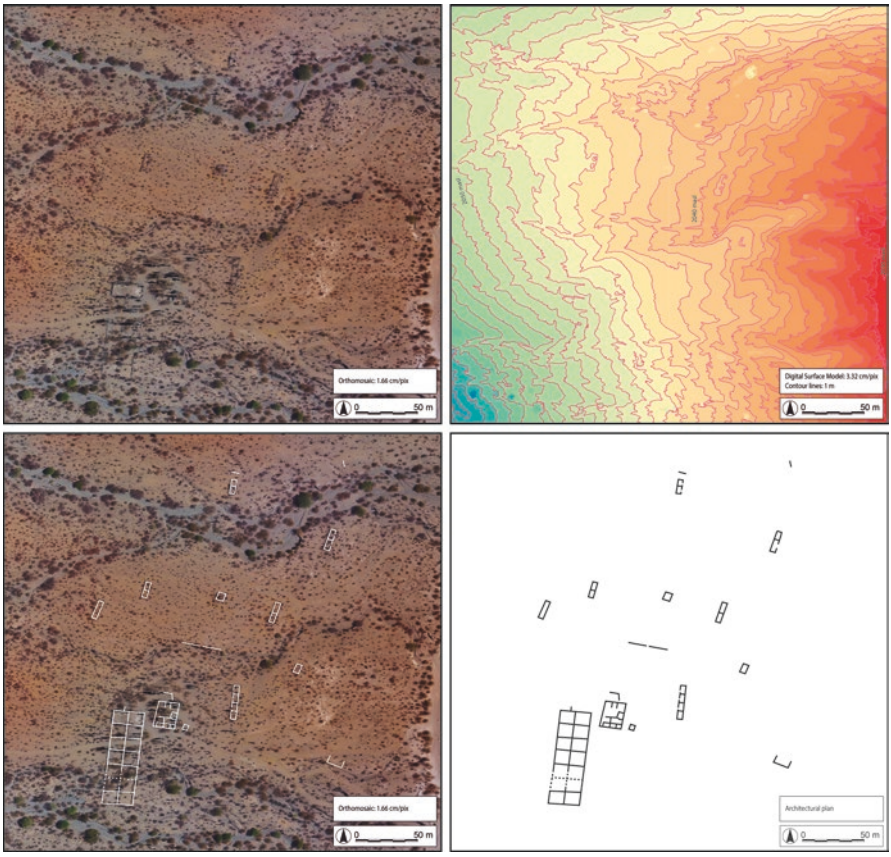

Fig. 11.3 Orthomosaic, digital surface model, and preliminary architectural and topographical plan of Inka site in Yocavil, NW Argentina, generated by UAV and photogrammetry (Author: Catriel Greco)

3 Discussion

Modern Western cartography supported by RS and GIS has been widely criticized for promoting predominantly scientific knowledge generation while neglecting other epistemological perspectives. These critiques are now widely recognized in several disciplinary fields (Rundstrom 1990; Harley 1992; Rundstrom 1995; Harley 2005; Wood 2010; Hacıgüzeller 2012). By the mid-1990s, increased criticism led to the introduction of PGIS, but not without new dilemmas and challenges (Poole 1995; Abbot et al. 1998; Stocks 2003; Elwood 2006; Wainwright and Bryan 2009; McCall and Dunn 2012).

One of the primary concerns is whether the use of these approaches implies a subordination of native epistemologies to Western cartographic norms with the consequent potential loss of Indigenous ways of knowing. McAnany et al. (2015: 7) warn, "Does the act of mapping homogenize communities for the purpose of

external presentation, particularly when legal land claims are at stake? […] These questions move us into the realm of situational ethics and, as such, yield no ready answer but must be contextualized". While we cannot ignore that Indigenous communities live in a globalized world and under nation state policies, the answer to these questions depend on the specific contexts wherein they exist. But precisely because of the power that maps have in establishing the hegemonic society, Indigenous peoples, marginalized communities, and other subordinate groups can use this rhetorical power to represent alternative visions of worlds and futures (Offen 2009; Sletto 2010). This "counter-mapping" (Peluso 1995) can become a powerful strategy to support the fight for Indigenous rights and sustainable livelihoods across Latin America (Denniston 1994; Gavazzi and Spyer Resende 1998; Finley-Brook and Offen 2009; Sletto 2009, 2010; Risler and Ares 2013; Kelly et al. 2017; ACT 2019). Nevertheless, it is essential to consider the purpose of different mapping projects. This step does not imply compromising Indigenous epistemologies, but rather co-constructing a process and a (temporary) product that serves as tools for dialogue with the larger society.

With the rapid technological advancement of geographic information science, new issues in PM approaches arise including developing local expertise in the handling of these technologies, the cost of software and computer equipment, hardware and software maintenance, among others. PGIS could involve technical processes and deter local participation. In Latin America, these conditions usually lead to a dependence on external technical expertise, as well as on financial resources managed by universities, government agencies, or international organizations including NGOs, that have agendas that may interfere with those of a given Indigenous community. For example, the archaeological mapping project with Maya communities in Guatemala discussed earlier (McAnany et al. 2015: 11), contracted a British-based company to provide secure networked storage for data points, and to programmable GPS units with community customized icons to make data collection user-friendly. This original proposal had to be shelved because the partnership with the software company proved too costly to renew even for an U.S. archaeological project.

Another relevant issue is the need of Western scientific standards to achieve broader "credibility", in conjunction with the issues that arise through the public exposure of TEK and LSK, which can lead to misinterpretations and misuse. As Sletto (2011) points out, hand-drawn maps that are cheap to reproduce and easy to read are usually adopted by local people for general use, meanwhile their computer or GIS counterparts are handled by external agents, which restricts accessibility, especially of the people who are supposed to be represented and served in those maps. The actions of academic researchers and practitioners in helping communities to develop, use, and make their maps public has been extensively criticized and debated (Rundstrom 1995; Johnson et al. 2006; Wainwright and Bryan 2009). To be effective, maps that show Indigenous land or traditional uses, for example, must position those claims within the state's territory and modern Western logic. Stocks (2003) notes that the first regional mapping of Indigenous communities in eastern Honduras and Nicaragua in the 1990s, under the sponsorship of Cultural Survival

and the World Bank, was done without establishing an agreement on boundaries between territories. They were both relatively short-term projects that produced maps with territorial overlaps that highlight areas of shared use or close kinship connections between communities. However, the maps were used by politicians to support the argument that if the Indigenous people could not agree on their boundaries -understood as fixed and concrete territorial limits-, the state had no reason to promote Indigenous land legalization. The pressure to demarcate those limits exacerbated by the capitalist logic of private property led to conflicts between communities.

A recent review of mapping projects in Latin America refers to this type of participatory approach as *radical cartographies*. Defined as the employment of modern technology with a radical use by communities (Sletto et al. 2020), PGIS practitioners have chosen "to bend spatial information technology to suit social needs and cultural expression" (McAnany et al. 2015: 7). These approaches involve an understanding that there are other epistemological conceptualizations of space that do not respond to Cartesian logic, and the search for creative ways to represent those epistemologies that are facilitated by digital devices and interfaces (Kelly et al. 2017). Mapping tools are now cheaper and more available, and a growing number of NGOs, academics, and lay citizens are engaged in innovative PGIS procedures.

To that end, counter-mapping should question preconceived knowledge and ideas of space, and thereby, lead to an epistemological and ontological re-definition of cartography itself. Rather than fully rejecting Western cartography and GIS, cartographers should use these as tools for cultural re-appropriation by employing them critically and aligning them with Indigenous cartographic traditions (Hirt 2012). Resisting the homogenization of spatial representations requires innovation in tool engineering, mapping methods, and forms of representation. Technological developments not only enable outreach to communities, but also facilitates intergenerational dialogues with younger generations who have fully embraced this technology for new ways of learning, working, and socializing. For example, among the Pemon people of southern Guyana and western Brazil, who currently reside within the Canaima National Park, the younger members are more engaged in tourism, tend to avoid traditional activities such as hunting, gardening, and fishing, and are also reluctant to embrace TEK because it is considered 'old-fashioned' or even environmentally destructive (Sletto 2009). Possible avenues for future research include the creation of new narratives and graphic techniques for incorporating spiritual and cultural experiences of place, recording intangible cultural heritage, and capturing the wealth of environmental knowledge and practical skills that are transmitted from one generation to the next.

There has been, in fact, a technological revolution since the first PM projects, with the growing incorporation of GIS and other recent innovations that seek to incorporate dynamic information such as stories, memories, pictures, and sounds. GIS maps can show either fluid or fuzzy boundaries as patterns of dynamic land use and toponyms, in addition to fixed boundaries required by cadastral land tenure systems (Kelly et al. 2017). Another technological frontier is the internet, which has led to rapidly developing web-based mapping technologies that allow Indigenous

people and their allies to use apps such as Google Earth, Google Maps, and other user-driven mapping interfaces. These apps facilitate participation in mapping projects, to publish online maps, and other data such as photographs and video. New internet technologies can make possible representations that are truer to the complex articulations of space, time, and culture that characterize Indigenous landscapes. For example, in the Cauca region of Colombia, the Fundación Minga developed innovative mapping projects resulting in "speaking maps", which are living maps that facilitate critical conversations and provide endogenous documentation of local knowledge among residents in Afro-Colombian communities. These talking maps demonstrated how memories and social relationships shape different conceptions of the territory (Velasco Alvarez 2020).

As Hacıgüzeller (2017) observes, digital cartographic interaction involves actions (switching layers on or off, changing symbology, or scaling maps up or down) carried out in playful ways. This makes it easy to consider digital maps as fleeting phenomena enacted through contextually situated practices, a consideration embraced by this performative turn in cartography. Approaches are currently being employed in 3D Projection-Augmented Landscape Models (3DPALM), that use physical 3D landscapes enhanced with geo-simulation models in GIS to support participatory planning, education, and cross-cultural knowledge exchange (Fig. 11.4). In Mexico, researchers used 3D-printed plastic tiles and the projection

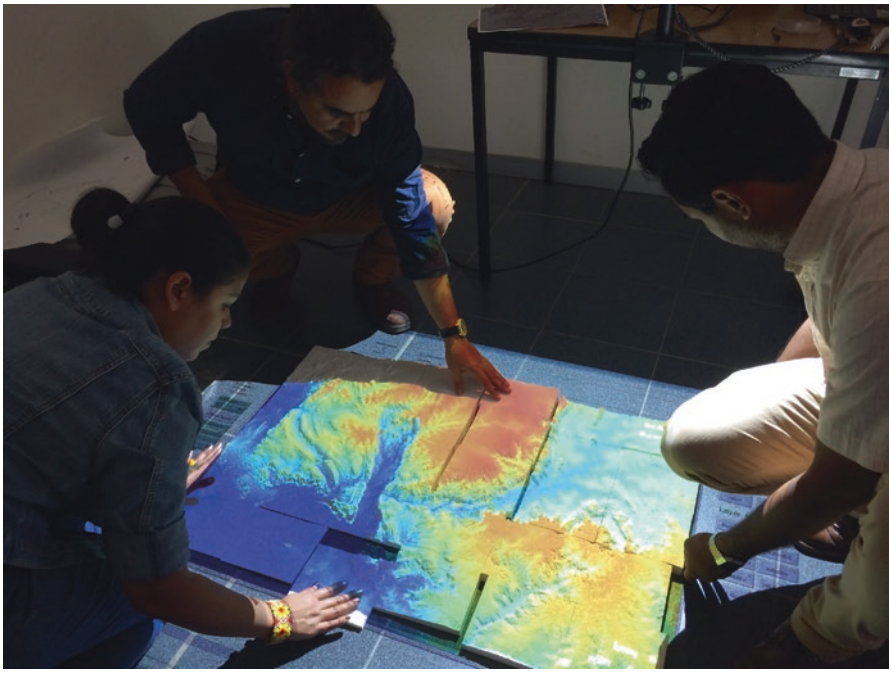

Fig. 11.4 A 3D Projection-Augmented Landscape Model using geo-simulation in GIS and 3D-printed plastic tiles

of multiple terrain layers to assists engagement with local farmers to explore sustainable agricultural practices. Models can also be displayed on a sand box for a more performative interaction (Fisher et al. 2019). In this regard, a major challenge is to venture out from conventional maps and replace them with cartographic representations that more richly depict how Indigenous people perceived the landscapes that they inhabit.

4 Conclusions

This chapter reviewed current applications of PGIS in archaeological research in collaboration with Indigenous, descendant and traditional communities of Latin America. Over the last several decades, Latin American and foreign archaeologists developed an array of techniques for examining the relationships between pre-Hispanic Indigenous peoples and the landscape wherein they exist. Yet, in recent years, archaeology has been called upon to do much more with this information, including engaging in research problems that are of interest to the Indigenous communities with whom they work.

The integration of LSK and TEK and geospatial science, mediated through the construction of common research agendas, enriches both types of epistemologies. For local and Indigenous people, archaeology can contribute to the identification of historical settlement locations unknown to them. This can be a critical tool for learning about the places of ancestors lost from the collective memory, a type of knowledge that is relevant to defending their cultural resources and exploring and preserving their heritage for future generations. Identity and culture are intrinsically linked to territory and local resources. For archaeological research, people's environmental knowledge gathered over many generations can significantly contribute to the way one interprets a site (Green et al. 2003). Further, oral tradition can greatly enrich our understanding of the different meanings of places. As a result, future endeavors in this field will require researchers to be aware of the role that the archaeologist plays within communities that have been disproportionately affected by social and environmental injustices that impact land rights, relationships with the landscape, and cultural heritage. In understanding these relationships, archaeology will continue to play a fundamental role as one of the few disciplines equipped to reconstruct the past and provide material evidence of human-environmental interactions to understand the present.

PGIS ceased to be just a tool for the generation of documents that can be read by external stakeholders, and over time, it became a process for the organization and internal decision-making of the communities according to their own understanding of human-environment relations. Today, it is used to document environmental degradation and resource extraction, as well as create comprehensive development plans and resource management strategies. In other words, PGIS has been adopted by communities as a tool for research and planning, contributing to their self-determination. The main challenge is how to effectively use these maps in their

internal affairs and in discussions with state administrators and decision makers. The "post- mapping" phase should be one of the most important and challenging parts of PGIS-related work. Maps should not be the end goal of the collaborative process but the beginning. Perhaps the most relevant questions for PGIS are: why do we want to create a map? What is its purpose? How will it be used, and by whom? PGIS should be understood as a social and political process that goes beyond the creation of maps and that involves more than purely technological processes. It should serve to strengthen community identity, allowing Indigenous people to take control of their lands not only legally, in terms of territorial rights, but through the development of social roots and sustainable management practices.

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