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Dependent or not? From a daily practice of Earth observation research in the Global South to promoting adequate developmental spaces in science and technology studies

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Abstract. Ever since the operation of the first civilian Earth observation (EO) satellites gained momentum in the 1970s, potential benefits and disadvantages of transferring space science and technologies, such as remote sensing techniques, have also been discussed in relation to developing countries. However, this debate has so far largely taken place at a macro-comparative level. This paper presents results from moving to the ethnographic micro level in southwest Nigeria. It sets the experiences of researchers from the Global South, who use remote sensing data, in relation to a critical review of (post-)development theory perspectives and corresponding discourses in postcolonial science and technology studies (STS). The paper discusses how researchers construct collective agency towards capacity building as a shared liberatory language in relation to an amalgam of experienced and contested places in the EO community. At the intersection of STS, geography and the arena of development policies, these experiences create their own spatial references to a developing niche that invites scholars and development practitioners to rethink and reorganise knowledge production and technologies in a postcolonial world.

1 Introduction

When I got to the riverbank there was no canoe to/and because of the determination to get the work done I had to/I had to enter the river. I was going/I did the survey on motorbike. My field assistant at the point told me he was not going to cross a certain river/he told me vehemently he was not going with me. . . . I took the risk, I took the risk. I muster with every energy I had in me, carried my motorbike. . . . I was able to cross [laughs]. (Interview 14, 4 November 2015)

November 2015. I had only arrived in Ile-Ife (Nigeria) 4 weeks earlier and was resting on my bed. The AC unit had stopped working 1 h before. I glimpsed outside the window, observing thousands of *Eidolon helvum* fruit bats that began moving from the university's campus site to another location

further south – their every evening ritual. When the AC had abruptly switched off, I immediately thought about the sign that I had come across in one of the nearby GIS laboratories a few hours earlier, in which researchers and students from affiliated African countries process data from Earth observation (EO) satellites: "Please shut down your computer at the end of the day and turn off of the UPS units to avoid battery run down at blackouts" – signed by the UN-affiliated training and research institute that also ran the guest house in which I stayed. However, what was I doing at this and other EO research facilities in southwest Nigeria in the first place?

In 2012, 3 years after the launch of South Africa's micro EO satellite SumbandilaSat, I came across a BBC article about this event. The headline suggested that a whole continent finally joined nothing less than "the space race" (Greenwood, 2009). After looking beyond media articles, I learned that remote sensing data, as the product of EO satellites, have

for a long time been used at various institutions in Nigeria towards Nigeria's territory. At this point, I prima facie considered Nigeria as a place with many distinguishing designations, such as a developing country, a postcolonial state, the "illusion" of a postcolonial state (for an in-depth discussion see Fawole, 2018), a state in the Global South, but also simply a state within the international community of states that is the recipient of often disputed developmental technology and knowledge transfers from the Global North. Having a background in both social anthropology and science and technology studies, leaving for Nigeria then became my decision after a relevant literature review that I present in the fourth section of this paper.

Following this, the research results that are discussed in this paper originate from my doctoral research on members of southwest Nigeria's EO community, their goals and their agency towards capacity building. By using tools, such as remote sensing software and geographic information systems (GIS), they utilise EO data towards environmental and societal questions in a region of the geopolitical Global South, just a few hundred kilometres north off the Equator. Whilst European states' *terrestrial* colonial rule over large areas of the Global South only slowly receded in the 1960s, by then the first EO satellites had already been launched by industrialised states to monitor global environments from low Earth orbit (LEO), as a new sphere of power (Morain, 1998). Here, this paper enters a complex postcolonial setting, in which EO technologies will eventually constitute one epitome of all the entanglements of the past 2 centuries, not only with humans' unprecedented scientific and technological advance but also consequences of colonialism, environmental degradation and eventually postcolonial developmental initiatives (Kadafa, 2012; Omeje, 2006).

Prior to collecting data, I had looked at decades-old discourses over potential benefits from transferring space technologies, like EO satellites and relevant equipment on the ground, to developing countries (Gall, 1983). In line with this, I had also looked at institutions from the Global North that invest in building capacity in developing countries towards obtaining and using data from EO satellites. Here, several scholars and policymakers had already contemplated national investments in space science in developing countries. This includes members of West Africa's largest agglomeration of capacity building in EO, which can be found in southwest Nigeria. The latter comprises two UN-affiliated regional training centres, as well as departments at universities and environmental institutions. However, after the review, any "Third World point of view" on the "transfer of space science and technology" to developing countries, as discussed at a symposium in Mexico in 1983, remained abstract. It was yet largely based on a macro-comparative analysis of national space programmes.

On the other hand, I looked at postcolonial perspectives at the intersection of science and technology studies (STS), anthropology, and other social sciences on the global transfers of science and technologies. Issues over dependency-creating actions and calls for alternative modernities in the South are only two of many standpoints that are discussed. Various scholars from both the South and the North contemplate paradigm shifts towards how we think about the essence of being postcolonial in terms of politics and transferring and producing science and technology (for example Fawole, 2018; Mavhunga, 2017; Tousignant, 2018). Borrowing the words (not the argument) of Zeleza, in much literature *Africa* is then often discussed between the priorities of aspiring to utilising "modern technological leap-frogging and good political and scientific leadership" and (alternatively) realising "its own modernities in a world of multiple, often conflicting, modernities" (Zeleza, 2003:30).

Against the background of these two perspectives, I wanted to understand the following: what is the everyday place of remote Earth-orbiting EO satellites on the ground in a postcolonial geopolitical setting? In other words, what do Nigerian researchers' standpoints and agency towards capacity building in yet another potentially dependency-creating global community of practice imply for (1) the practice of EO research towards (postcolonial) local territory and (2) towards rethinking and reorganising science and technology in a postcolonial world at the intersection of STS and developmental policies?

When I refer to capacity building, I follow a definition of capacity building that Cohen (1995:409) articulates with reference to Shafritz (1986). In our context it can be translated as strengthening a researcher's capabilities and efficiency towards their utilisation of remote sensing data for societal issues (from planning to evaluation; see also Sect. 4.3).

Following this, this paper addresses an already existing "impasse" regarding developmental paradigms (Schurr and Verne, 2017:126). It contributes to visualising both asymmetries and promising symmetries in global knowledge production (Dumoulin Kervran et al., 2018) towards environmental, societal and economic challenges by critically discussing opportunities for developing a niche that can suggest a way forward in building capacity for *global* EO research through pronouncing the case of local agency. The paper further critically discusses how the niche eventually brings postcolonial STS research even closer to developmental discourses and the community's transnational responsibilities.

Accordingly, in this paper I begin by introducing my methodology. I then have a more detailed discussion of the literature review to explain why answering the above questions is relevant for guiding related EO policies and developmental discourses in the postcolonial arena of STS and other social sciences. In the main discussion I relate this review to the empirical data. By doing so, I suggest how STS, together with other social sciences, can further help in finding a way out of an impasse that we often encounter in relation to developmental paradigms (Schurr and Verne, 2017:126).

2   Methodology and methods

Reviewing relevant literature, I soon encountered the abstract use of the divisive attribute *indigenous* in relation to building capacity in space science in emerging economies. I eventually used the attribute as a sensitising concept (Blumer, 1954, in Bowen, 2006:2–3) towards different methodologies that compete for an understanding of science and technologies in a postcolonial world. With my aim of understanding the geographically and socially dispersed practice of using remote sensing data in southwest Nigeria and considering the situational complexity in historical and societal terms, my actual methodology comprised a multi-sited ethnographic approach (Marcus, 1995), accompanied by situational analysis (Clarke, 2005). I conducted the fieldwork in southwest Nigeria between October 2015 and April 2016. An additional 2-week research stay in Enschede (the Netherlands), and my attendance at two EO conferences (in Uganda and South Africa) in 2014 and in 2016, framed my research. Here, the 2014 conference of the African Association of Remote Sensing of the Environment (AARSE) in Johannesburg became an entry point to the field, when I made the acquaintance of researchers from African countries. After my research stay in Nigeria, the subsequent biennial conference in Kampala in October 2016 then constituted an opportunity to present some of my results and receive feedback. However, before this conference, my chosen methodology had guided me to several research institutes and university departments across southwest Nigeria, such as surveying and geoinformatics, geography, remote sensing and GIS, forestry, veterinary science, and ecology. Finally, 1 month before the conference in Kampala, my multi-sited research in Nigeria had also guided me to the Faculty of Geo-Information Science and Earth Observation at the University of Twente in Enschede, the Netherlands (ITC). The reason is a unique relationship between ITC and the EO research community in southwest Nigeria, which sheds additional light on distinctive places and social worlds of knowledge production towards transferring science and technologies in a postcolonial world.

I in total conducted 90 semi-structured and/or non-directive interviews and 13 focus groups with researchers, technical staff and students, who relate themselves to EO research through their intellectual and practical activities (Table S1 in the Supplement). I imported the audio files into the qualitative data analysis software NVivo and transcribed my handwritten memos and field notes. As part of situational analysis, I began to codify data (open coding) during my research stay. After the research, different codes became "robust" in relation to my observations and were "densified" into bigger substantial analytical "categories" (Clarke, 2015; Schatzman and Strauss, 1973). As part of my multi-sited ethnographic approach and to understand relevant practices in the situation, I participated in and observed researchers' day-to-day routine in different places, such as offices, GIS laboratories, seminar rooms and corridors. All this required sampling (McNeill, 1990; Hammersley and Atkinson, 1983). I paid attention to knowledge-related interactions and connected elements and began following relevant paths. In the context of "member-identified categories", this further included my dialogue partners' advice on whom I should also meet (Hammersley and Atkinson, 1983:45–53). Furthermore, to gain a more in-depth understanding of the objectives and agency towards building capacity in using EO data, I also analysed EO-related documents that had been produced in Nigeria, such as theses, lectures, research publications, syllabi, legal texts, teaching materials (textbooks) and newspapers. With the same aim in mind and in line with constructing new sensitising concepts in situational analysis, I also introduced a focus on life histories (life stories and narratives) at the beginning of some interviews (McNeill, 1990; Plummer, 2001; Pascale, 2011). This allowed me to pay attention to my dialogue partners' experiences and evaluation of events (Cortazzi, 2007; Clarke, 2005). Finally, I produced memos, wrote field notes, and took photographs as visual aids towards my memory (after consent) and to document the talk about denotative and connotative meanings of objects, such as of analogue satellite images that I found in one of the GIS laboratories. This has improved my understanding of the historical context of the research situation (McNeill, 1990; Mitchell, 2011; Plummer, 2001).

3   A contemporary perspective on *Africa's* EO/space activities – between optimism, pessimism, cynicism and climbing a "space technology ladder"

Understanding the historical context of transferring EO technologies to Nigeria begins with a literature review. Already more than 40 years ago Walter and Ugelow (1979) emphasised the link between serving socioeconomic needs and missing environmental protection in many developing countries, where "environmental problems . . . are not the product of affluence, but of poverty" (Walter and Ugelow, 1979:102). Since their additional remark that such a principle of cause and effect is not written in stone (Walter and Ugelow, 1979), much indeed has changed. Not only have primarily industrialised countries launched many EO satellites (Morain, 1998), but both actors from outside and on the African continent increasingly argue for the use of EO data to protect the continent's environment and serve African countries' socioeconomic needs. One year before I left for Nigeria, all this became important in the Paris Agreement on combating climate change. The document frequently refers to the special needs and concerns of developing countries, including the assistance that shall be provided, such as relevant technology transfer and cooperative technology development (United Nations, 2015).

Several programmes already address specific environmental issues in developing countries, such as deforestation. For example, international conservation aid that Nigeria receives is provided by donors, such as the Global Environment Facility (GEF) (Bare et al., 2015). Nigeria is further involved in one of the UN-initiated programmes that focusses on "Reducing Emissions from Deforestation and Forest Degradation" (REDD+). This strategy is based on incentives in the form of a "financial value for the additional carbon stored in trees or not emitted to the atmosphere" (Corbera and Schroeder, 2011:189; Maukonen et al., 2017). In Nigeria, related socioeconomic entanglements are reflected in a combination of declining oil revenues and increasing deforestation. Together, they constitute one reason for Nigeria's engagement with REDD+ since 2009 (Asiyanbi et al., 2016; Maukonen et al., 2017). In 2017, Nigeria's Federal Ministry of Environment then made some recommendations on how the initiative can potentially benefit from additional tools and knowledge, including an "enhanced in-country capacity for spatial analysis" with a focus on GIS tools and available data sets across Nigeria (Maukonen et al., 2017:42). This can comprise "a combination of remote sensing and ground-based forest carbon inventory approaches" (UNFCCC, 2016:7).

This appreciation of remote sensing/EO data from satellites is not new. Since the 1980s, several organisations and initiatives with not only a specific focus on creating awareness of remote sensing and GIS amongst African policymakers but also of other space activities, have developed. For example, the African Association of Remote Sensing of the Environment (AARSE) was officially inaugurated in 1994 (Adeniyi, 1994b). At the same time, remote sensing eventually often became part of superordinated *space* agendas and narratives, where EO satellites in low Earth orbit are only one of many envisaged technologies in space. For example, later in 1999, a "30-year strategic space-policy agenda" was adopted in Nigeria, with EO being one component (Isoun, 2008). In the literature, a discussion of space sciences for Africa's social and economic development is then also often accompanied by the vaguely used attribute *indigenous*, which became a sensitising concept in my research. AARSE's newsletter of 1994 introduces the reader to the component of "indigenous understanding" of EO technologies as part of "scientific and technological capacity development": this development was needed on the African continent to contribute to regional and international environmental agendas and the related establishment of an EO infrastructure (Adeniyi, 1994a:13).

Regardless of the essence of the attribute *indigenous*, activities on the African continent that relate to space sciences in general are not simply met with approval. Looking at media articles that were published between 2010 and 2016, a differentiation between EO and other space-related ambitions is largely missing. By borrowing the words of a blogger, who referred to one of these articles, I argue that many headlines and articles appear "half patronizingly, half cynically" (Nielsen, 2011). They often imply the continent's almost *exotic* position regarding space sciences. The BBC's article "Wanting Space: Africa's Journey to Space begins on the Ground" (Baker, 2012) mentions Nigeria's introduction of a communication satellite, two EO satellites and related partnership with a UK-based satellite manufacturer. Other articles focus on the economic reasonability: "how can poor countries afford space programmes?" (Economist, 2013), and the BBC states "to Western eyes, it may seem rather inappropriate to launch space programmes in sub-Saharan Africa, where nearly *70 % of the population still lives on less* [than] *$2 a day*" (Kalan, 2013, emphasis in original).

Discourses in media are complemented by academic frameworks to contextualise the implementation of space science in developing countries for policy recommendations. Wood and Weigel (2012) analyse the "evolution of satellite programs in developing countries" and introduce the "space technology ladder" (STL). It is a taxonomy of national space activities, where operating national EO satellites constitutes the second stage on a linear path to a nation's full space capability. The STL reminds one of comparative developmental models, such as Rostow's (1960) five stages of growth that each economy shall pass. Similarly, Leloglu and Kocaoglan (2008) introduce a "space technology pyramid", and Harding (2013) speaks of tiers, whilst Giannopapa (2011) refers to user types. Eventually, several authors who look at the implementation of space science in developing countries express some optimism regarding developmental impacts, provided that sensible decisions are made (Esterhazy, 2009; Jason et al., 2010). However, some authors also identify various structural challenges (Jason et al., 2010) and acknowledge the northern research community's rather sceptical attitude towards space capability in developing countries (Leloglu and Kocaoglan, 2008). Regarding sub-Saharan Africa, one reason might be a largely missing comprehensive understanding "of how space applications are utilized by African actors and how cooperation between Africa and Europe is organized and conducted", as Giannopapa (2011:99) suggests when she refers to the European–African partnership's "First Action Plan (2008–2010)" that also promotes development through space applications. This includes platforms that aim at supporting space-based and in situ Earth observation capabilities of "African users" (Giannopapa, 2011; EUMETSAT, 2016). Also John (2009) argues that the "effect of space agencies in developing nations is not well understood". She emphasises that most relevant studies remain repetitive, such as by either highlighting "economic growth" through space-science-related activities or by considering such investments misguided in a developing country context.

Overall, in media articles, policy declarations and relevant academic literature, superordinated national space programmes remain the analytical focus in a linear macro-comparative framework towards capacity building in space sectors in developing countries, with a focus on policy

documents, databases and secondary literature. Supporting arguments for climbing the *space ladder* are reiterated in continent-wide declarations, such as the Mombasa Declaration (2012) on Space and Africa's Development, AARSE's (2014) Johannesburg Declaration, and the African Space Strategy (African Union, 2017). Looking at plans for an African space agency, Martinez (2012) discerns recurring comparisons to multilateral space agencies in other parts of the world, with remote sensing capabilities for socioeconomic development, health, resource management and environmental protection being significant elements in this respect. Against this background, this paper contributes a micro-level study that further complements an already existing corpus of policy-focussed literature from outside Nigeria's space science arena and also valuable publications from within Nigeria, such as Isoun and Isoun's (2013) *Why Run before Learning to Walk?*, Abiodun's (2013) *Space in the Revitalization of Nigeria's Economy*, and Akinyede's and Boroffice's (2011) *Nigeria's Quest in Space*.

At the same time as the impact of the developmental transfer of space technologies and science to sub-Saharan Africa remains abstract, this literature review also hints at discourses towards framing the future of science and technology agendas in a postcolonial world and sub-Saharan Africa in particular. We eventually find ourselves in a setting in which several academics aim at understanding how we arrived at an impasse regarding developmental paradigms (Schurr and Verne, 2017:126) and how we can set more ethical and historically sensitive academic and non-academic goals in this respect. Accordingly, the following section elaborates on why understanding the implications of Nigerian researchers' agency towards capacity building in yet *another* potentially dependence-creating global community of practice (EO as part of space research) is important.

4 Transferring science, technologies and a Global South – developmental, postcolonial and spatial concerns

Developmental narratives of climbing a space technology ladder for societal and economic benefits that consider anything from, as Harding suggests, China's launch capability of satellites and manned missions to a small satellite-related software company in Zimbabwe (Harding, 2013:x), co-exist with persistent public stereotypes about most developing countries' fractured relationship with technologies and science. These stereotypes are particularly pronounced towards sub-Saharan Africa (Giannopapa, 2011). This section discusses why these two perspectives together are (1) not only powerful in further entrenching an already existing impasse regarding developmental paradigms (Schurr and Verne, 2017:126) (2) but also in bringing about an opportunity for developing a niche for change. In this niche academic discourses on science and technologies in a postcolonial world

(such as at the intersection of STS, anthropology and geography) and research on a particular practice in the space arena, like EO in Nigeria, can further contribute to visualising both asymmetries and symmetries in global knowledge production (Dumoulin Kervran et al., 2018). Towards addressing environmental, societal and economic challenges, this niche can critically suggest a way forward in building capacity for *global* EO research through pronouncing the case of local *agency*. It eventually brings STS research even closer to developmental discourses and the community's transnational responsibilities.

4.1 Developmental concerns and postcolonial STS

In 1980, when Nigeria's Rivers State University was opened, it was believed that "the hard cutting edge of science and technology, as institutionalised in a University" can control local socio-environmental issues, as Nigeria's former minister of science and technology Turner Isoun recalls (Isoun, 1987:31, 65–68). If this means following a purportedly universal "model of industrial modernity", as Dibua, a US-based historian from Nigeria (Dibua, 2006:143), critically discusses, we are also confronted with a post-development discourse-related pessimistic view. This view considers unsustainable structural change, resource consumption and dependency instead of economic uplift (Hilty and Hercheui, 2010; Heeks, 2010). Though this issue is far from closure, we indeed still face an entrenched "overarching development rhetoric" (Pieterse, 2001:40) that often reduces developmental challenges to technological and knowledge (science) issues (Smith, 2009:19–20). In line with this, the exploitation of developing countries as dependent consumers in a *periphery* has become a prominent concern (Pieterse, 2001; Ya'u, 2004; Cherlet, 2014). Sub-Saharan Africa then is the geopolitical area that is usually most often confronted with determinist stereotypes about being a mere passive recipient of socially determining innovation and science from the Global North (Macola, 2016; Mavhunga, 2017). This issue can in part be translated to the dated but still applied model of a self-referential and basic research-producing core in Europe and North America that stands in *theoretical* contrast to dependent institutes in large parts of a peripheral Global South (Hwang, 2008; Dumoulin Kervran et al., 2018).

With the aim of countering this dependency narrative, development practitioners finally increasingly consider technology and knowledge production as being embedded in social and cultural processes in the South (Ellen, 2002). Whilst essential, the anthropologist Peter Redfield contemplates issues with this new emphasis on the local, when "locality in human affairs" is put in moral "opposition to the proliferation of global metaphors and transcendent claims made on behalf of capital and science" (Redfield, 2002:791–792). Any spatial and temporal components eventually constitute a challenge in studying the local in relation to apparently universal science and technologies, as Redfield (1996:792–

793) underlines elsewhere, when contemplating how colonial history became part of the space age (ESA's launch site in French Guiana). Acknowledging the complexity of spatial constructions eventually is key to understanding knowledge and technology production and transfers in a postcolonial world. Here, physical proximity or constructed spatial similarities might not always match the social arenas that we construct (Livingstone, 2003:6). For example, Lagos in Nigeria lies on the same longitude as the eastern surroundings of Paris (Île-de-France) but does not count to a geopolitical West.

This leads to the question of postcolonial STS. STS research itself has been further developed in the South, and social science studies use STS approaches towards studying scientific practices in parts of the global South (such as bioscience). Questions of power, the consequences of colonialism, hybridisations, unbundling the dichotomies of South and North, essentialising the latter, and science between the poles of liberation and features of colonialism are part of the latest discourse (Dumoulin Kervran et al., 2018). Here, much of what is at stake in postcolonial STS relates to thoughts also Chakrabarty (2000) had, where "European thought and history", as embodied in various concepts, are reconsidered. It is neither about questioning concepts like "scientific rationality" nor social scientific concepts and theories that are associated with Western institutions. He rather invites us to acknowledge their narrow normative essence in global terms. The idea of an everlasting related "incompleteness" in large parts of the Global South is challenged. In line with this, Kenrick and Lewis (2004) suggest a "relational" approach towards local attributes, such as *indigenous* practices or knowledge, to highlight the plurality of both struggles and resilience in a postcolonial world. These co-exist with the idea of *modernisation* and neither represent incompleteness nor developmental delay (Chakrabarty, 2000).

Close to this, postcolonial STS offers a standpoint approach that encourages those who are considered as being "at the peripheries of Northern modernity" to express "science and technology concerns" (Harding, 2008:7–8, 134–135). In this theoretical setting, "localness" is often thought of as being essentially tied to one of many global knowledge systems with their potentially unique epistemologies and other characteristics (Watson Verran and Turnbull, 1995; Harding, 2011). Occasionally, the whole African continent seems constructed as a multifaceted yet distinct knowledge system. For example, Mullen Kreamer points at a limited appreciation of "African concepts about the cosmos" with reference to an exhibition that focussed on demonstrating the relationship between "Africans" and their utilisation of what they observed in the night sky, such as in relation to rituals and agricultural practices (Mullen Kreamer, 2012:13–14). Whilst standpoint perspectives should be appreciated for the political commitment, "epistemological pluralism" is contested (Anderson, 2002; Anderson and Adams, 2008). In this context, we also encounter "strategic essentialism" for more telic

purposes (Dumoulin Kervran et al., 2018:297), such as the decolonisation of universities in Africa, where universities have "Africanised" their university personnel and where we now increasingly find discourses on Africanising epistemologies, pedagogical approaches and whole curricula, inspired by local cosmologies and ontologies (Nyamnjoh, 2019).

Often science and the West are as much deconstructed as they remain points of reference in postcolonial STS. For example, Mavhunga argues for a "hermeneutic and epistemological" move that acknowledges that "the same concepts we use to analyse northern-made technology and science must be the same ones we extend to an analysis of African thought and practices" (Mavhunga, 2014:16). This statement sets science and technology from the North apart from "African thought and practices", whilst claiming universal epistemological principles (Dove et al., 2009).

Accordingly, one central postcolonial STS provocation is to demarcate *where* and *why* the local (both geographically and socially) begins and to define the goals of any approach in *developmental* terms. We not only have elements of a Western social-constructivist STS perspective but also an empirical agenda, where the postcolonial "articulates an ontology that ties knowledge to location as a singular and essential quality of place" (Abraham, 2006:210), including calls for alternative developmental paths (Dibua, 2006; Jasanoff, 2002). Against this and my methodological standpoint, my research eventually followed Abraham's discussion, who considers a postcolonial lens appropriate if we do not isolate the South from the North and rather consider an "empirical response" (Abraham, 2006:217). Scientific practices and locations of EO researchers became the focus and revealed the "uneven circuits of global science" (Abraham, 2006:211, 217). Here this paper joins studies on other areas of science in a postcolonial context, such as Anne Pollock's (2019) *Synthesizing Hope*. She looks at the postcolonial power dynamics in South Africa's drug research, the places of producing relevant knowledge and structures that accompany science in the South. Perhaps the aim of this paper is best described by another recent and detailed study on scientific practices in sub-Saharan Africa, like Noémi Tousignant's work on *Toxicology and the Problem of Capacity in Postcolonial Senegal*. Her research made her call for

> histories not just of scientific problems and knowledge that cross paths with African scientists but also fine-grained, uninterrupted views of what it has meant to be a scientist in Africa, both on and off the trajectory of international "capacity building" and of global histories of science and medicine. These stories can tell us what capacity is, how it is made, kept, and lost, in relation to the specific stakes of what existing or missing capacity might be used to act on, in other words, in relation to what "good science" in both episte-

mological and moral terms might be. (Tousignant, 2018:146)

This paper acknowledges that with the North and South, we deal with challenging points of reference towards questions of how we want to organise and think knowledge and technology production in a postcolonial world. If the case study in this paper is defined as central in exposing asymmetries and symmetries in global EO knowledge production and in further elaborating developmental perspectives in postcolonial STS, this also happens in consideration of additional spaces that EO inevitably touches on. Here, spatial discourses in geography are likewise of paramount importance.

4.2 The additional postcolonial space towards participation in EO research

The relationship between the ground and what we refer to as outer space for thousands of years primarily was one of intimate horizontal observations and related astronomical observations in vertical direction. As anthropogenic objects, EO satellites have first entered this relationship less than 60 years ago. They are now periodically visible from most inhabited areas, and these areas are conversely observed from space. In other words, the orbital paths of these technologies describe a new layer that has already become part of discourses in relation to terrestrial politics and geography. In 2007, MacDonald made the case for "a critical geography of outer space" by reminding us how Earth's "sea" has already been critically considered in relation to "knowledge and power where philosophical, scientific and aesthetic discourses intersect with socio-economic, technological and political forces" (MacDonald, 2007:594).

If we further follow James Scott's (1998) contemplations in *Seeing Like a State*, one may carefully draw analogies with the observations that are made by EO satellites as being embedded in long-term practices of contemporary "modern statecraft". In preparation of discussing related negative consequences of governments' engineered interventions, Scott describes how the social and cultural complexity of local environments has eventually often been administered through the lens of "a standard grid". With the aim of handling spatial complexity, cadastral and land maps were soon produced by means of uniform scale and standardised surveying instruments. The resulting "synoptic view", that is primarily useful for uninformed outsiders, then in theory allows states to understand and control "its subjects and their environment" by means of categories. At the same time, they leave aside most elements of a "functioning social order" (regardless of the essence) (Scott, 1998). Instead, the focus is on attaining a systematic approach to specific interests, such as supposedly carefully designed agriculture and profit-yielding forestry. As this approach disregards much social history in relation

to trees and plants, the consequences can indeed be negative (Scott, 1998).

The related legibility, such as in the form of maps, can in parts be translated into the view from space. Scott refers to a "ground-level confusion" that is left behind by a "bird's-eye view", where the topography becomes like a canvas that communicates order (Scott, 1998:58). This excluded context that is often described as *indigenous* can not only comprise people's tacit and cross-generational knowledge towards ever-changing local environments but also a vertical relation, from the ground *via* low Earth orbit. For example, with some groups, specific observations of the night sky have been directly linked to scheduling agricultural practices and rituals (Mullen Kreamer, 2012). Medupe recalls how Dogon elders in Mali told him that "the rising of the Pleiades above the rock cliffs of the Dogon landscape indicates that it is time to plant millet, their staple crop" (Medupe, 2012:86). Following this, in the 1990s, when the implications of computer-assisted geographic inquiries became a discourse in industrialised countries, Curry (1995) considered the huge number of data as also leading to an alienation from people on the ground. This new "Cartesian space and technical, chronological time" could then be paralleled to much of Nigeria's urban and rural environment that in the name of EO research would benefit from an aerial perspective (Curry, 1995:78–79).

Any observation of local EO practices or support for relevant capacity building was thus preceded by what could be described as the following postcolonial asymmetry: appreciating the synoptic view is eventually embedded in powerful acts of legibility (Scott, 1998), with an orbit that suggests universal insights by initially acting towards a "narrow frame of reference" from an anthropologist's and a naturalist's perspective (Scott, 1998:12—3). As Scott suggests, *legibility* "implies" the centrality of the viewer, endued with "authority" over "selected aspects of the whole society" (Scott, 1998:79). Notwithstanding the impressive evolution of space technologies, including accompanying environmental objectives, satellites since 1957 have implicitly confronted the ground in relation to postcolonial issues. This also raises questions of participation in Earth observation and the assimilation of a larger historical perspective. For example, NASA's mission specialist Thomas D. Jones (2001:252–261) described his observations of Earth's complexity from a "superb vantage point" as a "reeducation in geography". In addition, Jones' NASA colleagues on board Skylab had extensively observed "the inland delta of the Niger River" southwest of Timbuktu in Mali. Unlike the beliefs of local "agricultural experts" that most slash-and-burn activities take place before the rainy season, the astronauts observed extensive activities (smoke plumes and fires) during the transition to the dry season, as Muehlberger and Wilmarth (1977:154–155) describe

The Skylab astronauts' observations were important clues to furthering our understanding of how

cultural activities can affect arid lands, not only in the Sahel but potentially throughout the world. The contrast in observations is a result of the very limited area that can be studied by ground or aircraft studies versus the synoptic view observed from spacecraft. (Muehlberger and Wilmarth, 1977)

With EO, we hence also deal with vertical questions of space and power, in the context of technopolitics with "the hybrid forms of power embedded in technological artifacts, systems, and practices" (Hecht, 2011:3). In addition to the above discussion, developing countries now belong to international forums that negotiate space law and call for a fair distribution of remote sensing data of their territories (Williams, 2005). Overall, low Earth orbit has become an additional social and political geography of concern to which the EO community in Nigeria is connected and which STS, geography and anthropology can jointly address. This additional space of mapping Earth is joined by more and more actors that map the planet and visualise its environmental conditions, according to their own paradigm. For example, global companies and NGOs bring in new goals and practices in the dichotomous context of producing global maps and of highlighting temporal local environmental observations. Regardless of their focus, they do not yet counter the continuous "objectification of Earth", where global maps that have been constructed under the influence of "political and cultural presuppositions", contribute to the entrenchment of a "whole Earth" abstraction (Grevsmühl, 2017). This development not only hides much complexity, including additional power relations, but probably also hides collaborative opportunities towards expressing the urgency of tackling climate change (Grevsmühl, 2017).

4.3   Constructing the analytical lens

At this juncture, we have a setting in which the use of EO data and related capacity building enter a horizontal and vertical construction of social and cultural power relations, between the alleged peripheries and centres of transnational knowledge production. This setting benefits from an analytical lens that allows us to address some of the theoretical concerns through complementing less essentialised standpoint approaches that are empirically constructed. Here, two concepts – (1) communities of practice (CoPs) and (2) heterotopia – are particularly helpful for looking at researchers' *agency towards capacity building* in EO. They become part of, in Abraham's words, "historically situated intersections of the political economy of place and unequal location within transnational circuits of knowledge flow" (Abraham, 2006:211, 217). Their integration at the intersection of theory and empirical data in part 5 is illustrated in Fig. S1 in the Supplement.

4.3.1   Capacity building

Before introducing the two concepts, the almost diluted term *capacity building* (Cohen, 1995) needs some additional attention. It in general describes all those strategies by different entities that shall support development. The term is now used in a broad context, ranging from "professional education" to development aid and a "national development culture" (Cohen, 1995:408–409). One public-sector-related definition, that Cohen considers useful, describes a situation in which support towards drafting, managing, implementing, and evaluating any strategies and programmes that aim at improving "social conditions" in societal entities like communities is needed. This requires strengthening the capabilities, efficiency and competencies of relevant individual people, such as "department and agency heads" (Shafritz, 1986:79; in Cohen, 1995:409). In the case of EO research, this can be translated into the following: strengthening a researcher's capabilities and efficiency towards their utilisation of remote sensing data for societal issues (from planning to evaluation).

Such capacity building only became a focus from the 1980s onwards. Mere technical assistance (TA) in its developmental context of unidirectionally transferring "knowledge or techniques" to developing countries was increasingly considered a deficient approach (Morgan, 2002:1, 10). This was accompanied by questioning a "simplistic" dichotomy of pass and fail (Morgan, 2002:4). Here, Morgan reminds us that "systemic and societal dysfunctions" are circumstances that from the outset limit any impact of TA (Morgan, 2002). Despite the new focus on capacity building, the African continent in particular has been under critical observation, often accompanied by a simplistic macro-comparative dichotomy of optimism and pessimism, such as towards building capacity in EO in developing countries. Accordingly, this research has not considered a pass/fail lens. It rather paid attention to a critical issue that many international development organisations have not been able to develop – "the capacity to build capacity" (Morgan, 2002:10, 20). Such an understanding can be supported by considering the following concepts.

4.3.2   Communities of practice (CoPs)

Any understanding of the genesis of a "capacity to build capacity" can benefit from paying attention to collective learning processes. Here, the helpful concept of communities of practice (Wenger, 1998) has its origins in Lave and Wenger's (1991) original focus on understanding communities beyond connections (network analysis) by offering a new path towards articulating the "human experience" behind learning processes for meaning making (Farnsworth et al., 2016:7). Lave and Wenger considered a social process in which experiences and stories are shared outside classroom settings, in an environment where certain skills are used and required, and where related challenges and solutions are collectively identified, such as between new and experienced

practitioners (Li et al., 2009). In this case, a community of practice as a "learning partnership" involves a different structuring process than a team as "a task-driven partnership" (Farnsworth et al., 2016:6).

With this concept, we may focus on (1) social participation in relation to other peoples' activities and (2) the mutual construction of identities and imperatives of doing and understanding one's actions. Action and belonging then describe the relationship with any attribute that can be ascribed to a *community*. At the same time, individuals participate in various communities of practice that all address their unique objectives. For example, as three of countless examples, a night shift group in airport operations, a specific therapy group and an environmental research group can constitute a community of practice. In each case, elements, such as rituals, routines, symbols, words, practices and stories are developed to address both converging and diverging developments. These elements of a *shared repertoire* support coherence by providing the members with tools of expressing membership, identities and meaning in relation to the world. The repertoire remains ambiguous and can be adapted to new circumstances, whilst shared beliefs or meanings are no precondition. Whilst the concept is part of a theory of learning and can tell us much about structuring processes in organisations, it can likewise provide an understanding of capacity building beyond institutionalised processes (Wenger, 1998).

4.3.3 Task-driven mutual engagement and learning in a CoP – an emergent social structure

Let us imagine a situation where people in the first instance work towards an environment in which they can pursue their tasks. *Mutual engagement* is at the heart of understanding a community of practice, where the meaning of actions towards this or other goals is negotiated beyond mere communication and information relationships, allegiance, titles, affiliations with an organisation, or geographical proximity. Especially the latter case is relevant, as sharing an office can mean less for forming a CoP than mutual engagement over a long distance. Furthermore, also an almost homogeneous background, such as in terms of life experiences, prior expectations, political views and interests, is less important than the joint learning process in relation to a subject, such as analysing EO data. This comprises aspects of communicating and discussing with each other. During this process shared understandings and practices will develop as much as individual capabilities, where roles are further defined. Complementary and meaningful connections between those who hold different pieces of knowledge and skills then matter most. Accordingly, a central aspect that members share is *learning*. It is a source of an emergent social structure. People invest in learning through practice, as part of who they become. This process is accompanied by the development of relations of mutual accountability, such as in terms of sharing information and knowledge with others (Wenger, 1998).

At the same time, any engagement in a community of practice can be characterised by conflicts and complex webs of power and dependence. Disagreement can however constitute a way forward, as members need to negotiate towards achieving their goals or indeed develop coping mechanisms in relation to certain instances, such as missing appreciation and resources (Wenger, 1998).

4.3.4 Negotiating the historical context and conditions in a CoP – "inventiveness"

In line with this, another important aspect is the larger context in which CoPs develop over time, such as in relation to a specialised industry or academic discipline. Various social and institutional aspects lead to implicit and explicit conditions and requirements that members of a CoP respond to with "an inventiveness that is all theirs" – as part of achieving their daily goals or responsibilities and making their work bearable/enjoyable. This can comprise ways of overcoming lacking resources and time constraints. Whilst communities of practice can have a long history, they might also have developed most recently or are temporary, such as in the case of coping with the recent pandemic and geopolitical conflicts (Wenger, 1998).

4.3.5 Boundary objects in a CoP

However, most important and in line with *situational analysis* (see "Methodology and methods"), communities of practice are not isolated. They involve various external relations with other communities that for example produce relevant resources, demand services or support the practices of a community. Here, so-called *boundary objects*, such as technologies, documents and other artefacts that surround a CoP, often relate to many other communities that do not share specific practices. EO data for example relate to engineers, researchers and software developers (Wenger, 1998). They allow coordination but do not necessarily translate the meanings and practices of attached communities. Boundary objects have various characteristics, such as modularity, where each perspective relates to specific fractions of an object, but also standardisation, where information that belongs to the object can be locally decoded and applied. At the same time, not all artefacts are boundary objects nor are all objects encoded, such as for example a forest, around which various perspectives (such as EO) are coordinated by different CoPs.

4.3.6 Knowledge brokering in and between CoPs

As Wenger (1998) further discusses, in turn, an individual participates in various communities of practice and can *span boundaries* by bringing elements of one practice into another realm of practices. Doing so can be described as *brokering*. This act connects different communities and opens up "new possibilities for meaning" and coordination. Some people are

more keen to broker than others and thus might prefer staying outside the core of their practices (Wenger, 1998). This concept of a "knowledge broker" has been discussed by different authors, such as Lingard et al. (2007), who emphasise that knowledge brokers "build shared models of understanding", with "sites of social negotiation that can redress the problem of fragmentation of knowledge and information" as something that knowledge brokers can achieve (Lingard et al., 2007:503–506). When Lingard et al. in this case consider an "interdisciplinary health research team", the focus is on the translation, coordination and integration of "diverse perspectives" (Lingard et al., 2007:501, 506). In other cases, brokers are described as translating knowledge between, for example, a science community and policymakers (Pielke, 2007). There are many examples that can illustrate such a brokering practice: an employee might successfully transfer procedures from their day-time work to their leisure affiliations, if considered useful. This usually depends on successful translations and alignments of information, the broker's status and also their ability of negotiating perspectives, dealing with ambivalence and different expectations, or judgements towards their presence in a community, as well as their facilitation of transactions between practices (Wenger, 1998).

At the same time, connecting to members of another community should be supplemented, such as by an artefact that accompanies people (e.g. EO data) (Wenger, 1998). This is what Wenger (1998) describes as "visit a practice", where immersion leads to a better understanding of the mutual practices. At the same time, this, in my own case, also involved *observing* the third boundary encounter. Here, Wenger (1998) refers to delegations (participants from each community) that meet and where any negotiation of meaning takes place among members of each practice. This not only comprises the mutual observation of negotiation practices but also a "boundary practice", in terms of doing something together, to form a connection and engage in collective brokering. For example, this can be a project between local researchers in forestry and visiting researchers from a different discipline. In the end, multiple levels of involvement can exist, with peripheries developing at which mutual engagement is less present, and outsiders can temporarily experience relevant elements of another community (Wenger, 1998).

4.3.7   Delineating CoPs

Most important is that "a complex social landscape of shared practices, boundaries, peripheries, overlaps, connections, and encounters" (Wenger, 1998:118) is what converging and diverging communities of practice constitute. Institutional structures have an influence but cannot control peoples' engagement in practice towards achieving a task. Institutional structures often rather comprise various CoPs than matching the boundaries of one. This leads to the elephant in the room. Where does a community of practice start and end, and which

of the many "imaginable social configuration[s]" is a CoP (such as a nation, entire city or company)? Regarding EO, one could, for example, consider the entire EO/environmental or even space research community, all environmental researchers in Nigeria, or at a much smaller level, five colleagues who often enjoy lunch together. Wenger (1998:124–125) thus provides some indicators, which exclude both a "narrowly defined activity or interaction" (such as occasional interactions) and "a broadly defined aggregate that is abstractly historical and social" (Wenger, 1998), where any disconnectedness and a multiplicity of perspectives would be marginalised. Hence, indicators that are relevant, inter alia, include "local lore, shared stories, inside jokes, knowing laughter", shortcuts in communication, shared discourses, and a "rapid flow of information and propagation of innovation" (Wenger, 1998:125–126). Many elements of the repertoire, such as jargon and tools, will be imported. However, a certain level of local production and learning-oriented interaction between people should take place beyond what one might otherwise describe as a personal network.

4.3.8   Relevance of CoP in this paper

Overall, a CoP remains an analytical category, not something that is named or reified. In analogy to historically clustering visible stars in the night sky, a community of practice can belong to various constellations, between which they negotiate their position, such as a university and any other organisation (Wenger, 1998). In this context, all above-discussed aspects will be relevant in the following discussion of the empirical data.

4.3.9   Heterotopia

As we look at practices that eventually relate to capacity building towards addressing local environmental challenges, another concept is relevant regarding the imprint of different CoPs that can co-exist in a region in relation to transnational constructions. Here the historical context in which a CoP is situated in terms of a governing institution becomes relevant. The, in this case, useful concept *heterotopia* was coined by Foucault, when he contemplated

> places that do exist and that are formed in the very founding of society – which are something like counter-sites, a kind of effectively enacted utopia in which the real sites, all the other real sites that can be found within the culture, are simultaneously represented, contested, and inverted. Places of this kind are outside of all places, even though it may be possible to indicate their location in reality. Because these places are absolutely different from all the sites that they reflect and speak about, I shall call them, by way of contrast to utopias, heterotopias. (Foucault, 1986:24)

Four of six principles, that according to Foucault can constitute a heterotopia, are of relevance in further understanding the role of knowledge brokers towards capacity building in any local EO community of practice, in relation to their historical context and institutional boundary conditions. (1) For example, according to Foucault, a heterotopia can be a "single real place" where "several spaces, several sites that are in themselves incompatible" are juxtaposed, such as a sacred Persian garden that "was supposed to bring together inside its rectangle four parts representing the four parts of the world" (Foucault, 1986:25). (2) Another principle relates to a break with "traditional time". According to Foucault, this principle is, for example, embodied in museums. (3) The fifth principle speaks about the "opening and closing" mechanisms of a heterotopia. In this case, the heterotopia is not "freely accessible like a public place". (4) With the sixth principle, we eventually encounter a heterotopia's function in relation to remaining spaces. It can be a space of illusion "[o]r, else, on the contrary, their role is to create a space that is other, another real space, as perfect, as meticulous, as well arranged as ours is messy, ill constructed, and jumbled". Think of a "compensation" like colonies, as Foucault suggests (Foucault, 1986:26–27).

5 Actors, agency and places in EO research in southwest Nigeria – building a CoP

In this section, I not only discuss the construction of EO-related CoPs but also I likewise argue that I indeed entered an international *heterotopia* in a "jumbled" fraction of a postcolonial world that further delineates the local CoPs' practice of building capacity towards capacity building in EO research. I begin with those experiences of local researchers that describe some of the conditions in which these constructions take place.

5.1 The experience that grounds liberatory experiences with EO

I wake up early in the morning; we go to the stream. There is nothing like borehole, there is nothing like tap water. ... That is the water that we drink, that is the water we bath, we wash and everything.... So, you see. It is in the heart of the rainforest. Growing up there enabled me to start appreciate nature and appreciating my ecosystem. (Interview 26, 16 December 2015)

Developing a collective understanding of what GIS and remote sensing data mean in relation to their disciplines goes beyond researchers' simple appreciation of a transferred "research tool" (Goodchild, 1995). Researchers in southwest Nigeria appreciate that they can now occupy an elevated perspective regarding an environment that is in peril. This environment includes the stream in above-mentioned child-

hood memories (Oyelaran, 2011). Much of this appreciation is based on individual experiences with "conventional" methods of data collection and analysis at the intersection of Nigeria's natural and social environments:

Now again, traditionally you want to go on ground and look at those illegal routes, but we know that going on illegal routes is not safe by road. So, you may not likely cover all of them, but from the high-resolution image, you can actually get all of those things and then we can analyse them as much as possible. (Interview 58, 24 February 2016)

One geographer's words at the beginning of this paper further describe the tedious work of accessing rural areas due to missing infrastructural development and environmental depletion (Omeje, 2006), which in turn promote social conflicts and insecurity (Omeje, 2006). Though my experience was limited, moving around indeed became one of my primary challenges, which I only mastered with the help of my hosts. The educational trip to a gold mine gave me an idea of how any field inventory is an experience of disruption. Most researchers will primarily rely on their own cars to go to the field. In addition to occasional fuel shortages and losing time on bad roads, they usually arrive at their destination before sunset as overland drives are considered unsafe during the night. A local textbook is forthright about the potential risks of land transport and lists "theft/robbery" and "kidnapping" (Uluocha, 2015:104). In the end, managing to carry questionnaires to remote areas is only a first step. The continuous deprivation in many villages and unfulfilled pledges of development often make them reluctant to participate:

In fact, some people are hostile. Once they see you coming with a form they say "sorry do not come to us". They will tell you "some people were here yesterday, two days ago, last year they promised to come back and do something for us, they did not come back and you are coming with another form". (Interview 12, 27 October 2015)

Furthermore, the new vantage point is also appreciated in a historical context. Missing data in a largely unplanned environment and missing topographic maps, of which the latest versions often date back to the 1960s and 1970s (Soneye and Akintuyi, 2013; Ogedegbe, 2014), can then be partially compensated:

And the most unfortunate thing is that Ibadan just spread without any town planning. Till today, till today [raps on his table], there is no town plan for Ibadan, no town plan. (Interview 48, 6 February 2016)

Remote sensing in combination with GIS for many researchers eventually has the potential of ending a vicious circle in which a researcher's agency, through conventional

methods, is thwarted by "disorder on the ground" that most researchers intend to address:

> You have problems of sanitation, problems of providing water, electricity and also transportation. So, GIS now will become a useful opportunity to try to see how we can solve all those problems. (Interview 24, 7 December 2015)

At this juncture, recalling the theoretical discussion about critical cartography and a disenfranchising view from low Earth orbit (Sect. 4.2) seems important. Uluocha, a geographer from Lagos in Nigeria, who himself supports the use of satellite images, indeed points at information that remains invisible. He reminds us how "Africans have always communicated cartographically in various ways" as part of their "indigenous cartography" (Uluocha, 2018:27). People's communication of long-term experiences with geographical features has been taking place through different channels. In the case of "geo-onomastic channels", geographical names, such as toponyms, hydronyms (water bodies) and ethnonyms (group names), "descriptively communicate landscape information" (Uluocha, 2018:32–34). Eba Odan, the original toponym of Ibadan in Nigeria, means "the place between the rainforest and the savanna", as Uluocha explained to me (Interview 93, 20 April 2016). And in relation to what can at least be partially observed from space, Uluocha recalls how, when he was young, the elderly explained to him that the Imo River in Nigeria would at regular intervals overflow its banks, adding that the elderly "did not need satellite imagery" for such knowledge. This knowledge comprises long-term observations, experiences and cultural analyses (Interview 93, 20 April 2016), such as that described by anthropologists. In other words, we talk about people's intimate engagement with terrestrial geography that can now be observed from space. However, after the following empirical sections, the Conclusion will discuss that the use of EO is not eliminating this history but rather constitutes an opportunity to be integrated and to co-exist.

5.2   Meeting in the *agora* and becoming knowledge brokers

In consideration of these social and environmental experiences, the integration of remote sensing and GIS into Earth science disciplines in southwest Nigeria has its foundation in the long-standing connected experiences of individuals. This includes those "pioneers" (as many researchers refer to them), who had first encountered EO research in a wider global arena. It was in this arena where these researchers became *knowledge brokers*. Referring to the concept of a knowledge broker that was introduced in Sect. 4, their focus has been on the translation, coordination and integration of "diverse perspectives", through which they support *mutual engagement* towards shared EO objectives and a relevant joint *learning process* (Lingard et al., 2007:501, 506;

Wenger, 1998). This paper thus considers the construction of Nigeria-based EO research as developing CoPs, in relation to an amalgam of experienced places that create their own spatial references to the wider EO research arena. What does becoming a knowledge broker mean in this setting?

One relevant place that I encountered during my stay in Nigeria is physically located in Europe. ITC in Enschede (the Netherlands) is not simply a capacity-building institution in the Global North. It is a place where future knowledge brokers experience how researchers from all over the world join a productive *agora*. In this agora, members from a local CoP not only encounter members from other CoPs but also they jointly construct a superordinate CoP that in turn supports the delineation of the local CoP. The local CoP is where knowledge brokers from Nigeria return, in the context of supporting capacity to build capacity in EO research. Though one researcher, unlike many of his colleagues, had not attended ITC, he has a clear vision of such places in the wider arena and introduced the relevant notion of an *agora*:

> You know you come to the agora and you express your mind and you talk and other people also will contribute.... We call different people working in almost more or less the same area or the same idea; we meet. This is what I was doing, this is how I did and so on and so forth. (Interview 24, 7 December 2015)

5.2.1   Mutual engagement and a joint learning process

Following this vision, ITC actually shows several characteristics of a *community of practice*, as discussed by Wenger .(1998). In the words of one ITC alumni, researchers enter "a big roundabout where you meet plenty people, plenty nationalities" (Interview 23, 3 December 2015). His colleague further recalls how he realised something special about this roundabout, calling it an "African village almost [laughs]" (Interview 28, 6 January 2016). The central experience at ITC is having encounters with other students from the African continent and the rest of the world, who all contribute additional perspectives and research problems to a joint learning process.

In relation to a CoP-related learning process, this developing literacy is grounded in the experience of people joining under one roof to learn more about the same technology and science for their socioeconomic development:

> You see people that are from your place pursuing what you are pursuing.... Because you see Ugandans, you have Zambians, you have Ethiopians, you have Chinese people coming. It gives you a very broad sense of appreciation of the values that they place to data. (Interview 28, 6 January 2016)

As part of a CoP, "they eventually sustain dense relations of mutual engagement organized around what they are there to do" (Wenger, 1998:74):

Because there you see the various possibilities of using/putting geoinformation to use .... Because I was completely illiterate of those developments as of that time. My stay in Holland has widened my understanding and the need for GIS applications. (Interview 28, 6 January 2016)

When we appreciate the *agora* as a locatable learning arena of constructing an EO-knowledge-related CoP, ITC can be considered a continuously evolving embodiment of socially distributed knowledge production that focusses on applications and transdisciplinary integrations (with reference to how Nowotny et al., 2003, discuss agora). Researchers from all over the world *negotiate* various EO research problems in relation to different disciplines, as one researcher at ITC underlines

It is not for us to decide what kind of knowledge people need. People who come to study here, they have a very strong say in the composition of their own academic programme. (Interview 97, 8 September 2016)

Modules shall ease the integration of disciplinary knowledge into remote sensing and GIS in the boundaries of ITC's standards and those of the Dutch academic system. Specialised knowledge can then become appropriate by being a choice in relation to issues in different places across the globe. This in turn is based on a shared understanding of EO data and its analysis:

Before they arrive, we have talked to their bosses and together with the students and their bosses, we have identified research topics that they are going to work on.... What the people get out of their programme is *appropriate knowledge*, because it is exactly what they need. (Interview 97, 8 September 2016)

5.2.2   A shared repertoire

In this agora, knowledge production is appreciated as a collective process in relation to various spatially dispersed developmental and environmental issues. In this context, and as part of the "repertoire" of the related construction of a CoP (Wenger, 1998:83), utilising remote sensing data and GIS as relevant "ways of doing things", as well as discourses about the technologies' meaning, constitute a shared liberatory medium during their development as knowledge brokers; researchers then gain additional application-related literacy with a wider understanding towards translating, coordinating and integrating different perspectives.

The repertoire also comprises stories, gestures and symbols, as well as forms of expressing membership. They are all part of constructing this CoP (Wenger, 1998:83). ITC's official ceremonial mace is one example. It is "carved from

African ebony" and a gift from one former director of southwest Nigeria's African Regional Institute for Geospatial Information Science and Technology (Disco, 2010:106, 118). In the 60th anniversary publication of ITC, the Dutch institution also emphasises that in 1986 one researcher from Nigeria was the first-ever PhD candidate at ITC (Disco, 2010:96–97). Several researchers in Nigeria recall this, with one of them underlining the importance of having a community member who has been the first *African* to have completed a PhD there (Interview 30, 13 January 2016). These specific elements in an extended *repertoire* have entered both CoPs through travelling knowledge brokers between Nigeria and the Netherlands. Shared discourses, symbols (the mace) and lore then begin substantiating the links between various global CoPs that show similar objectives and conditions.

5.2.3   Negotiating the historical context

During my stay at ITC, I soon realised how this mutual understanding is constructed in a carefully planned place. ITC's annual international food festival is only one observation regarding "community maintenance" as an intrinsic part of working for coherence in relation to mutual engagement in a CoP (Wenger, 1998:74–75). One researcher described how ITC being "the centre everybody wants to go to" to acquire knowledge is also based on the communication of such experiences (Interview 48, 6 February 2016). In this context, ITC shows elements of *negotiating* the historical and social context of its CoP, including resources and constraints (Wenger, 1998:79–80). ITC indeed emphasises that in 1950 the institution was not simply founded in the context of technical assistance but has further fought for their mandate of capacity building *for* a developing world (Disco, 2010). After eventually joining the Dutch academic system by becoming a faculty at the University of Twente, ITC still aims at "maintaining its traditional identity as mediator between 'western' technologies and the practical needs of geoinformation organizations in less developed countries" (Disco, 2010:118).

5.2.4   Knowledge brokers, repertoire and learning

Researchers, who have been to ITC and other EO institutions abroad, have described how they have learnt to appreciate this form of capacity building. The founder of an EO and environmental science laboratory not only describes how his stay at ITC has led to an increased effectiveness in his research area but also articulates a related responsibility to integrate such in Nigeria. In the local CoP he found "his unique place" and gained "a unique identity" (Wenger, 1998:76) by also integrating other researchers' knowledge and standpoints. His role as a knowledge broker comprises his skills of constructing shared understandings of problems and finding solutions:

That kind of exposure at ITC and interaction helped me in coming back to really (fine-tune) my

own strategies in implementing the initiative. (Interview 53, 17 February 2016)

Integrating, elaborating and teaching shared understandings means to again evaluate these in relation to socio-environmental issues in Nigeria:

> Someone did it in Israel or someone did it in Australia or did it in India. You try to model it in Nigeria, or you try to model it in Senegal, and you see how it will work and those people, that community will benefit from it. (Interview 24, 7 December 2015)

In this context, several younger researchers appreciate ITC for promoting *Africa*'s capacity through their alumni (knowledge brokers): "what they have done for Africa, . . . because some of them they are alumni here/at the end of the day became like the frontiers that you know helped" (Interview 26, 16 December 2015). As part of their jargon, they appreciate individual senior researchers as their "icons", "pioneers", "key figure[s] of GIS in Nigeria", if not Africa, or indeed as their "ITC products". These knowledge brokers had "developed locally and further got exposed internationally" and can hence open the eyes of those who have not yet been exposed, as one head of a department of remote sensing stated (Interview 30, 13 January 2016). Following this, some younger researchers are aware of their own role in this collective learning process. They might themselves have travelled to institutions abroad or directly liaised with senior knowledge brokers. At the same time, their role is primarily one of maintaining and directing capacity in a situation of perceived increasing disorder and diminishing resources. They work on developing an independent local network and ties with the wider arena to maintain their personal and institutional capacity. Cultivating relationships with contacts from abroad, such as former supervisors, can be substantial in this respect. They can facilitate grant applications and conference participation (Interview 3, 15 October 2015), and as long as the relations are not discontinued, as one alumni of the International Space University (ISU) in Strasbourg remarks:

> Then she will use the linkage between the International Space University library, you know they have foreign partners, and she will get the paper for me and send it to me. But after some time, I lost the link with her. (Interview 9, 22 October 2015)

Regardless of the age, *exposure* is a recurring key term in the context of being aware of one's role as a knowledge broker. This role not only implies the duty of brokering embedded ways of producing problem-oriented knowledge but also embodies it. This is expressed by those who receive such capacity and those who broker it:

> When they said I am the brainbox of the department, I cannot be a brainbox. It is part of my *ex-*

posure, my experience that has given me the leverage, the opportunity to serve. . . . And the interaction will go a long way to encourage me to continue my research. (Interview 33, 18 January 2016)

This role is embedded in constant reflections of experiences abroad against local experiences. This includes contemplating potentially naïve ideas of going to Europe. By this, researchers further substantiate their own role as *returning* brokers of knowledge and that of their local CoP:

> Yes, because I saw some Africans there, suffering. (Interview 48, 6 February 2016)

In this context, the whole role of institutions like ITC and of becoming a knowledge broker has to be further considered in light of (1) other *international institutions* in and outside Nigeria and (2) visiting scholars from abroad.

5.2.5 The CoP's next-door heterotopia

For example, two researchers advised me to visit a southwest-Nigeria-located international institute that does research on agriculture:

> The place is like . . . , you have people from all over the world, scientists from all over the world of different countries working there. (Interview 22, 27 November 2015)

I soon began to understand the mentioned "difference". Before entering the well-maintained green compound, we had to register. Upon entering one of the functionalist buildings, I experienced a place with expats, who I had not met outside. It is a place where Nigeria and other tropical countries suddenly appear like an ordered microcosm with means that most researchers outside this institute's walls lack – especially in terms of access to data. Considering the previous discussion of Foucault's concept heterotopia in relation to CoPs, the "other" (sixth principle) then, for example, also comes in terms of access to primary data. In this heterotopia the collection of data usually is separated from the work in the GIS laboratory and often conducted by colleagues. This further delineates the more tedious practices in the EO-related CoPs outside the walls of this international institute:

> [our scientists] went to cassava farms and they were able to monitor the incidence, the severity/ I mean the incidence of these diseases on the cassava and then they came with the georeferenced information of incidence. (Interview 67, 1 March 2016)

5.2.6 CoP versus heterotopia

The second aspect that needs to then be considered in relation to being a knowledge broker in a CoP outside this heterotopia is related to experiences with inviting researchers

from abroad. Already before the Covid-19 pandemic, some researchers perceived that any transnational "exchange of knowledge" has steadily declined. For example, a few weeks after one researcher told me that his former host, a professor from Germany, was "coming over to Nigeria" (Interview 33, 18 January 2016), he called and told me that his host had cancelled his travel plans. Here, security concerns do cause headaches for those who invite researchers from abroad:

> If you are not interested you would not travel down here. You have the fear of this Boko Haram, you will not know that Boko Haram is not, is not operating in the southwest. (Interview 39, 25 January 2016)

Foreign EO researchers, who come over, might nevertheless leave early for other reasons, as one emeritus geographer remembers:

> He [my guest] told me this story later on. He said one day he woke up and called [anonymised colleague], saying "Mike, what the hell are we doing in this place?"... Gerry would talk about myself. If anybody who works in that type of condition, that I worked, that he saw and survive, he must be a genius [we both laugh]. I say "I am not a genius. I am only very determined". (Interview 65, 29 February 2016)

Here, researchers emphasise a self-evident need for local (capacity) development. Accordingly, until today the pioneers of this integration continue to play a central role as knowledge brokers in capacity building.

5.2.7   Capacity to build capacity – the shared objective

In summary, as one researcher explains, teaching the science behind EO and GIS means to develop a "critical mass" that values capacity building (Interview 22, 27 November 2015). At the same time, knowledge brokers emphasise that any recognition of their role is primarily developing in a situation where capacity is restricted in the first place (Interview 13, 29 September 2015). This makes the development of collective capacity to build capacity a matter of priority, as one researcher explains with the analogy of a "one-eyed man in the land of the blind", wanting to see for everyone. Building capacity then comprises small steps, such as teaching individual researchers processes of georeferencing, digitising maps and analysing data. One lecturer argues that knowledge brokers need to be aware that such work will often only show tangible results after years but that transferring the philosophy of capacity building is a foundational appreciated step: "when you start expanding your tentacles into the system, at least the philosophy you imparted into them, will now germinate" (Interview 24, 7 December 2015). Any such commitment, however, must not be taken for granted, as one geogra-

pher reminds us. When somebody asked him why he did not just stay "in London and just disappear", he replied

> Let me come back and contribute. I still have positive mind that things will get better. (Interview 3, 15 October 2015)

Considering all this, what then is the wider condition of constructing the CoP in terms of a knowledge broker's agency towards building capacity upon returning?

5.3   Returning from the *agora* – boundary-object-related agency towards building capacity

Assumed *incompleteness* outside Europe (Chakrabarty, 2000) indeed is a flawed understanding. However, in local EO research this can be a daily collective experience regarding researchers' resilience towards postcolonial ecological dislocations. It is constructed through the experience of knowledge brokers, who translate between EO research in southwest Nigeria and a global arena. Concerning their limited access to EO data, software and other elements, researchers frequently mentioned related notions of "here" (Nigeria/West Africa) and "there" (outside Nigeria) and the common locational denominator "this part of the world" to reference their collective experience of scarcity in the EO situation. If we then consider EO data as *boundary objects*, my research supports the observation that despite a "new level of claimed international cooperation in EO" the management and distribution of "millions of data sets" remain yet largely uncoordinated (Neil, 2017). The United Nations' (1986) 30-year-old suggestion to grant developing countries access to relevant EO data under reasonable conditions remains unfulfilled for many EO researchers. This constitutes a *collective boundary-object-related experience* of often relying on free medium-resolution Landsat data (US Geological Survey, 2016; Belward and Skøien, 2015). Despite a collective appreciation of such data of medium resolution, the related need to lower one's sights is accompanied by frustration. One lecturer at a department of surveying and geoinformatics emphasises the data's limited value for applications that require data of higher resolution to, for example, discern building structures:

> I don't know the type of geospatial information you want to get from the 30 metre [laughs] if I am not doing just clustering or pattern combination or things like that.... I cannot work at the local government level using such data. (Interview 81, 29 March 2016)

A colleague at a department of geography likewise points out that in some cases you can neither do the research that you have planned nor make use of your actual capacity, such as in terms of software proficiency.

Whilst budgetary limitations and the need for careful decisions in acquiring the most "cost effective" remote sensing

data sets are also emphasised in general literature (Liu and Mason, 2016:277), in southwest Nigeria this process takes place at a different level. In addition to a potentially disembodying view from low Earth orbit (see Sect. 4.2), EO data become political in parts of the Global South. Here, EO data are archived in repositories that are experienced as geographically and economically restricted. Complex application processes for occasional data grants become an additional challenge in this situation, as I experienced myself, when one day, a senior researcher asked me whether I could help a PhD candidate with an application for radar data from a German satellite. Here, accessing EO data is often accompanied by barriers that are considered unnecessary at the intersection of local and global networks.

> Of course some projects have been funded by the EU, USAID and some other international organisations. Most of these data collected are in different depositories, in different . . . universities, organisations. There is really no standard of bringing them together. (Interview 22, 27 November 2015)

Researchers hence envision nothing less than the development of a ground-based culture towards data acquisition:

> It has to be institutionalised. It has to be seen as a culture. You have to go into that culture. If you cannot/it has been a culture in your own systems. (Interview 22, 27 November 2015)

This is a development that Areola (1986), a senior geographer, already mentioned as missing in the 1980s. The call for a national geospatial data infrastructure (NGDI) is still there: "and people will be well informed on the importance of sharing data/the importance of access to data, the importance of standardisation of data and then to use data as a platform to serve geospatial data for governance as a whole" (Interview 43, 27 January 2016). Another researcher adds

> Because whether we like it or not, SPOT [commercial high-resolution EO satellite] passes over Nigeria. . . . All we need to do is pay annual subscription for download. Now, given that scenario, we can monitor, we can monitor things like flood. (Interview 58, 24 February 2016)

The latest major review (2018) of the chances of implementing the desired national spatial data infrastructures in 12 African countries suggests that financial and human resources are not yet sufficient (Mwange et al., 2018). In the case of Nigeria, differences among two major geospatial data-related CoPs have for many years further impeded the implementation process (Interviews).

The scope of restraining developments on the ground comprises various additional elements that largely go unheeded in macro-comparative literature, as they are not directly considered typical for the EO/space research situation. In the Global North their continuous presence is either taken for granted (electricity) or not (yet) relevant (air conditioning). In Nigeria, however, their frequent absence is entrenched in the EO situation and private life:

> For the past/for the past four/five days no light here. There is no electricity. That shows you if an institution like this can be in darkness, I wonder what you think of people in town (another group member said "it is affecting the production"). (Focus Group 10, 4 April 2016)

In light of this situation, upon returning to Nigeria, as experienced knowledge brokers, researchers leave parts of the analysis of their environment to researchers from abroad. Any realisation of a liberatory agora in Nigeria is impeded by the daily need to pursue down-to-earth capacity development in relation to data, software, power supply and other elements (Clarke, 2015), such as workstations, air conditioning, handheld GPS and knowledge about the benefits of EO:

> We don't have data, but do we say we should fold our hands. . . . We have to keep advocating, advocating for people to first of all understand the capability and what it can do. (Interview 26, 16 December 2015)

Considering the limiting practices around *boundary objects* like EO data, maintaining related capacity in relation to a wider arena is part of the daily practice of many researchers. This comprises CoP-related mutual engagement (practices) towards achieving routines and a related *inventiveness* in terms of negotiating the historical context and conditions of the CoP. In this case, returning knowledge brokers and local researchers have developed a collective agency that I describe as *scouting resource provision* (SRP) (Thorpe, 2019). This practice is supported by a web of social relationships and constitutes an additional intermediary step towards participation in the global EO arena. In this case, based on experiences, researchers do usually neither rely on political entities nor national or transnational organisations and institutions. They engage in independent scouting for *relevant* materials and knowledge from both the local and the wider arena. Whilst specific materials and knowledge are sought, a researcher's agency of working around with available data and software remains a significant aspect of maintaining the momentum of research. This initially means scouting for foundational knowledge to better assess one's actual needs:

> And now lack of this knowledge has even made it more difficult in our own context. . . . Like somebody just called me now that he wants to use hy-

perspectral data.... But where are you going to get hyperspectral data? (Interview 26, 16 December 2015)

Accepting to adapt one's objectives to available data is hence another skill whilst scouting:

> If I want to work on 1985 for example, I look at the date that is available. There is not 1985 data. The next one is 1986. So, I will take 1986 and work on 1986. Because if I have to work on 1985, it might require that I will need to purchase the data and by the time I purchase a stream of data that might be required for the work, it might be too expensive. (Interview 9, 16 December 2015)

> But I expect that I should have access to better quality data, view hyperspectral images that have up to 50 bands and above, which will make my work much easier. But you know, for now I have to just make do with what I have or what I can have access to. It is the Aster. The Aster, if you apply to NASA as a privileged user, you can have access to it. But (even at that) you have limitations to the access you can have. Maybe you have downloaded like once or twice. (Interview 51, 8 February 2016)

In this situation also Google Earth has become an unexpected target in scouting for data. Researchers acknowledge that processing data from Google Earth is very limited in comparison to (raw) remote sensing data from original providers. Some researchers however advocate learning how to extract a few visible features from such secondary data, such as during the planning stage of their research (Interview 24, 7 December 2015; Interview 58, 24 February 2016). However, sometimes working around with what is available is not the solution and scouting for availability is. For example, one afternoon I ran into a geographer, who actually set the foundation for coining SRP. He told me that he was "scouting" for data by going to different institutions on campus, without any guarantee of finding adequate high-resolution images for his research on urban green infrastructure:

> You have to scout/that is the word/you have to run from pillar to post, begging people if they have ever come across such data. You know if you were to be in US or UK, you can just log into USGS and you have all these archived data and you could download, high resolution, superb for your work. (Interview 75, 21 March 2016)

Acquiring and physically scouting for data usually become a personal investment. One researcher remembers how he bought Ikonos data in Nairobi, where he went for further training, and how before travelling, he had to sell his car (Interview 39, 25 January 2016). Here, data-related scouting of-ten takes place abroad when researchers discern specific windows of opportunity after having covered travel-related expenses. These personal investments do eventually also benefit other researchers. They appreciate colleagues that invest resources in scouting and are willing to share acquired data:

> The moment I get myself out to the UK [laughs] or to Kuwait and I connect myself to the internet, I download all my files, whatever I need from the internet. That is what I do when I am out of the country. (Interview 81, 29 March 2016)

Any appreciation of access to resources, such as data and online tutorials (e-Learning), is only of value if a power-dependent stable internet connection is available. The long-known erratic nature of power supply is one of the elements that is most difficult to control in terms of a capacity maintenance. Here, scouting is again directly linked to the private realm:

> I went to a friend's office down down (!) the campus road yesterday to be able to find power, to power my laptop to be able to work. (Interview 9, 22 October 2015)

In the case of power supply, personal and departmental investments, such as in generators, inverters or solar power equipment, then also support other researchers. Most researchers also invest in their own backup internet connection by using their mobile phones for tethering. Where such investments are not feasible, scouting for internet access again can mean to literally look for windows of opportunity:

> And so, if I'm gonna use internet now, I will have to open my laptop and place it on the window (he demonstrates it), so I can receive signal. If I put it here, the signals will be very weak. (Interview 9, 22 October 2015)

Overall, SRP describes a process by perception. Personal intellectual and financial investments in provisions, including the communication of resources, become part of a collective CoP-related routine and inventiveness towards maintaining capacity. It is an internalised process in relation to a wider situation that allows for more stable provisions:

> In Nigeria we prepare for eventualities. You know when I travelled for AARSE conference in South Africa last year, I never sighted any generating plants [generators].... But here, you, you might have, let electricity go off, you'll be hearing noise [of generators] [imitates noise]. (Interview 1, 13 October 2015)

5.4 Returning from the *agora* – down-to-earth technological projects in an emerging social structure (CoP)

In this SRP situation, any enthusiasm for space-based remote sensing can thus perforce give way to small-scale technologies that operate close to the ground, such as UAVs/drones, that few knowledge brokers already promote:

> Repetitive coverage, you cannot take that one away from satellites. It will still be an advantage of satellites. But at least for some high-resolution mapping, maybe drones will take care of those ones in the [near] future. (Interview 22, 27 November 2015)

Here, capacity building also means to make the ground functional for "incoming" EO technologies, such as by gaining an in-depth understanding of the inner workings of handheld GPS, spectrometers, scanners, plotters and other technologies that researchers use. Furthermore, this also means building the foundation for independent developments, such as power supply:

> I told the HOD [head of department], "we have a local problem. We have electricity problem. We need to put up a system that will be less dependent on generator". That is how I came about with that inverter. (Interview 33, 18 January 2016)

A collective appreciation of similar developments, that require only modest funding, eventually prevails. It is further grounded in experiences in the wider space research arena in Nigeria. For example, researchers from one of the UN-affiliated training centres had been invited to join a Spanish professor's humanitarian satellite project. As affording to contribute their own satellite to a "constellation of small university-built satellites" was not an option, the team focussed on ground-based sensors that can support the measurement of desert encroachment:

> That is why rather than waiting for thousands and thousands of dollars for maybe the kind of satellite equipment and staff that we might need, I can buy a microcontroller, 2500 Naira. I'll buy components from [anywhere]. I can still afford that . . . you still work, you still show that this is possible. (Interview 15, 5 November 2015)

This approach is considered "things that are more down-to-earth" (Interview 15, 5 November 2015), as a necessary translation that allows us to develop a functional base for future projects. However, eventually even these developments are in danger of being impeded by the situation itself. The sustained lack of funding did not allow the team to travel to the north of Nigeria to calibrate the sensors. Researchers admit that it often is too "depressing to follow" such transnational projects that they have to leave despite modest ambitions:

> I know of a few satellites that were launched. It became too depressing to follow it. (Interview 15, 5 November 2015)

Despite many local researchers' SRP and down-to-earth focus in relation to boundary objects, the objective of going beyond *local capacity* in the medium term is promoted in different application cases. For example, in light of persistent cloud cover in the south of Nigeria, one Nigerian researcher promotes building local capacity regarding radar data from active sensors. During my stay she applied for data from Germany's TerraSAR-X to further develop relevant methods of data analysis in relation to specific physical features and socioeconomic fingerprints on Nigeria's ground. By this, she connects to what some researchers consider a lost capacity in radar data analysis that had partially been transferred by British consultants in the so-called NIRAD project (Federal Government of Nigeria and Federal Department of Forestry, 1978). Her related objective of leaving behind the role of a mere recipient of technologies is reciprocal in nature as any *appropriated* method development shall in turn be applicable in other places. This means to add value to radar data and eventually have a "voice in the field" (Interview 21, 13 November 2015):

> We are always the one following. So, we are looking forward to/I am looking forward to a time that we will be the one in front. (Interview 21, 13 November 2015)

Whilst researchers look for responsibility in the local situation, some researchers also discern missed opportunities, such as in the case of software development. For example, whilst independent programming of software in Nigeria is considered an alternative, those who are involved are aware that technology (software) from Nigeria might be considered inferior in the larger arena:

> Some of the programme language you need, some of them are advanced. You also need to get it, need to buy it. Then you also have to get some certain software and see how it works to design yours. (Interview 26, 16 December 2015)

In line with this and in the context of integrating IDRISI software from Clark University at one institution, one lecturer argues that mutual benefits of involving "local staff" in the conception of software had yet been largely overlooked. This would not be about cutting "the umbilical link" but about contributing to the development of software (Interview 24, 7 December 2015; Interview 32, 18 January 2016).

In consideration of all this, it is researchers' priority to guarantee that the designed functionality of EO-related boundary objects adheres to experiences and standards that have been acquired in a wider arena. Whilst valuable research has described how other technologies are repaired by transforming local resources to functional spare parts (for exam-

ple Bellucci and Zaccaria, 2012), this paper suggests to increasingly pay attention to *other users* of *other technologies* in other social worlds and arenas in sub-Saharan Africa. In our case technologies, data and knowledge are already considered *appropriate* for contributing to an understanding of the physical environment that has been severely impacted by a capitalist modernity. It is not in the interest of researchers to include potentially corrupting materials but rather to contribute to the boundary objects' applicability.

6 Conclusion

First of all, in line with social scientists like Pollock and Subramaniam (2016:953), this paper substantiates the importance of reassessing several Western developmental initiatives. It supports a critical discussion of outdated simplistic centre–periphery models, such as those that premise the unidirectional and global diffusion of what is often described as Europe's technologies, "science, rationality, progress, and enlightenment" (Pollock and Subramaniam, 2016). At the same time, the paper suggests that *in some instances*, alternative paths that are suggested in postcolonial STS discourses should be continuously revisited against what might inadvertently be rejected by adding studies to the new "fronts" of STS research and in-depth fieldwork in the South, as discussed by Dumoulin Kervran et al. (2018). The case of agency towards capacity building in EO research in Nigeria promotes a stronger sensitivity towards niches or rather communities of practice (CoPs) that in some experience-based instances support static and universalist models in addressing the consequences of colonial histories. Here, the EO research situation in southwest Nigeria highlights *agency* in the South that is directed towards participation in a global scientific arena, despite concerns over new asymmetries. This awareness can help related policymakers in deciding on more ethical and historically sensitive goals. In this case, the focus is on understanding why people do what they do and how they evaluate their daily practice. In line with Tousignant's (2018:146–149) study on toxicology in Senegal, this paper thus supports her call for understanding what capacity means in relation to scientific practices in sub-Saharan Africa. Here, "bigger but seemingly banal wishes – to have their own lab(s)", in our case are wishes of having access to required and appropriate EO data. This should not only make us think about our privileges in the North but also acknowledge how people in parts of the global South use their own resources to make *science* work for specific purposes (Tousignant, 2016).

In EO research in southwest Nigeria, ground-based scarcity constitutes the setting in which any envisioned capacity building develops. Based on their training at institutions in the wider arena, individual researchers have not only become *knowledge brokers*, but exercise a unique responsi-

bility in transferring and integrating knowledge upon returning to southwest Nigeria – as "capacity to build capacity":

> When you travel out of Nigeria to study in ITC that is capacity building. But when you can stay here within the country and develop people to have the skill to work that is capacity to build capacity. (Interview 53, 17 February 2016)

Knowledge brokers constitute the strongest links, as institutional relationships with the wider arena are often disrupted through the situation itself. The focus then is on maintaining capacity. This means working for a routine in relation to the wider arena, with scouting resource provision (SRP) as a central practice:

> And you know there are some of us that have a way of getting around our problems, perhaps, maybe some of this high-resolution imagery that you will actually need to do your work, when you look at the challenges of acquiring them, you find a way of looking for alternatives. (Interview 14, 4 November 2015)

Against this background, the actual CoP-based capacity building follows a "down-to-earth" approach. Knowledge brokering then means to take responsibility for the situation by creating a basis for capacity development that goes beyond SRP.

At the same time, entrenched determinist and *passive recipient*-oriented perspectives still exist in relation to the Global South, including additional "stigma" towards sub-Saharan Africa, as also one staff at ITC in the Netherlands reminded me. Accordingly, if the practices of science in the Global South are not appreciated in relation to participating in the consequences of a(n) (alleged) *Western* modernity, the many *communities* on this planet will all lose in the context of obsolete *binary concepts* of space that co-exist with environmental issues, which are not anchored in time and space (Schurr and Verne, 2017:137–138). Already before the Covid-19 pandemic, Schurr and Verne (2017) mentioned pandemics like Ebola as a prime example in this respect. We can only imagine what an *agency-focused appreciation* of science in the Global South could have further contributed to the work of millions of CoPs around the world.

> If our planet is going to be helped, a lot more of scientific research studies will have to be encouraged. . . . Our centre for example, is supposed to be an international organisation, one will expect that some people would have come and say, "please can you help us work in this area?" (Interview 9, 22 October 2015)

EO researchers in southwest Nigeria address the social, economic and environmental implications of colonialism

not by opposing related technological and scientific consequences but by participating in them with often unrecognised agency and rationales. If some pluralist postcolonial STS positions are carried too far, they paradoxically are in danger of in theory complicating this CoPs's access to wider arenas of science and technology. This is the case whenever the West has been provincialised at too many levels. Researchers rather see careful participation in a modernity that relates to worldwide capitalism (Jameson, 2002) as the most powerful agency in addressing its implications. They oppose becoming subalterns in another era of global inequality. In this era, knowledge production and technologies now also relate to spaces like low Earth orbit that again are largely within the power-related purview of industrialised countries (MacDonald, 2007; UNIDIR, 2013).

At this juncture it seems important to nevertheless recall the discussion of critical cartography and a potentially disenfranchising view from low Earth orbit. Supporting local agency towards capacity building in the context of transferred EO technologies and knowledge may raise concerns that we implicitly walk into the trap of supporting an outdated centre–periphery model. In this case we presume that the "scientist rhetoric of map makers" and their "computer-assisted methods and Geographical Information Systems" are coming from the North as a "normative" and epistemologically mythologised trap of objective science, as discussed by Harley (1989), whilst access to EO data through data providers from the Global North is limited. All this means that remote sensing data might not be the liberatory technology that it seems to be. Whilst these concerns should be kept in mind, EO-related liberation is not simply a transferred narrative.

First of all, Curry's (1995:78–79) related concerns about the potential neglect of what he calls the "lived space, or place, and human or narrative time" (Curry, 1995) eventually brings us back to the question of the *locale* and indigenous. The collective promotion of remote sensing data to primary data has indeed been critically discussed by one geographer at the University of Lagos. However, he scrutinises EO data in relation to its conditions of use. His reference to indigenous knowledge primarily signifies what might be left out if the appreciation of remote sensing and GIS is carried too far. He reminds us to not lose sight of environmental and social knowledge on the ground that remains invisible to EO satellites. A new sensitivity towards integrating such knowledge in EO research might actually mitigate some of the challenges that researchers face on the ground, such as the mistrustful villagers and missing historical data – which can induce appreciating remote sensing data in the first place (Interview 93, 20 April 2016).

Secondly, any potential EO-related "disenfranchisement" of humans on the ground (Curry, 1995) should be understood in relation to a researcher's specific encounters with the ground. Liberation then is different from any implicit claims of being more literate about the environment. For example,

when general literature refers to *potential* difficulties in collecting primary and ground-truthing data and hence suggests different methods of data classification (De By et al., 2012), in the case of southwest Nigeria, these challenges are entrenched in the research object (such as urban areas) and objectives (controlled development). In other words, here liberation is not a mere improvement of methods and methodologies, such as in terms of quantity, precision and efficiency. This is how GIS has for long been promoted in industrialised countries (Pickles, 1995). In our case, liberation is also not a mere modernist and positivist "switch from knowledge to information" or "unreflective GIS advocacy" that Pickles criticised in 1995. It rather is an appreciation of technologies that allow researchers to keep track of developments that often restrain their own capacity towards terrestrial environments in the first place.

At the same time, with the limited EO data availability, this supposedly ethical liberation probably points at the big elephant in the EO situation. In many cases and in most technical terms, the interpretation of satellite images still requires specific knowledge of features on the ground. In the case of southwest Nigeria, researchers *from* that region usually have gathered such knowledge since their childhood. Whilst this was articulated in several interviews and informal conversations, the related advantages in EO research remained nobly unarticulated. In other words, despite their situation, local EO researchers do not directly argue that they are potentially better suited to analyse EO data regarding Nigeria's environment than expats or colleagues abroad, or, as discussed, to even integrate *local knowledge* that remains invisible to satellites' partially disenfranchising synoptic view. In cases where local knowledge is appreciated by other research CoPs from abroad (or the mentioned "heterotopia"), this appreciation is not always linked to providing related EO data to promote researchers' full participation in the wider EO-related global CoPs. There are parallels to participatory mapping projects that exist in relation to Africa, where citizens can contribute to mapping areas for various reasons, such as disaster relief in OpenStreetMap or mapping trees in Collect Earth events. In these *mapathons*, participants do not need specific remote-sensing-data-related knowledge. As they usually temporarily contribute their knowledge, organisers of these events should however also consider their additional *inclusion* through adequate knowledge transfer (Arakwiye et al., 2021). Accordingly, returning to the discussion of a developmental impasse, this paper argues that STS researchers are well equipped to empirically address the new "fronts" of STS research and to contribute to itemising *developmental practices* in EO and other science arenas. They can deconstruct the dichotomy of North and South, whilst paying continuous attention to how essentialised units in terms of dominated and dominant parties are constructed (Dumoulin Kervran et al., 2018). We might otherwise lose sight of groups that produce knowledge and use technologies in a specific goal-driven transnational and intrinsic epistemological arena.

Here, ITC in the Netherlands, as one of the temporary CoPs where researchers become knowledge brokers, has for a long time resisted becoming part of a "self-referential system" of *Western* science (Hwang, 2008; Disco, 2010). I hence share Hwang (2008), Pollock and Subramaniam (2016), and other researchers' concerns, who point at the mutual relationships between the presumed cores of knowledge production and alleged peripheries. It is where people maximise their scientific agency, whilst emphasising their limitations (Hwang, 2008:129). The agency in southwest Nigeria is characterised by capacity maintenance and capacity development that transcends institutional and national structures.

Accordingly, through an empirical response, STS can help *provincialising* in a different context. One approach might be provincialising developmental perspectives that promote overly linear leapfrogging agendas, such as by means of those taxonomies that remind one of Rostow's (1960) five stages of economic growth (here the space technology ladder). This can emphasise the standpoints and telic agency of various scientists/researchers in the Global South. I relate to Mawdsley's (2015) invitation to further critically theorise a "complex and turbulent" economic "Western-dominated international development regime" that yet entails old normative hierarchies. At the same time, looking at the situational scarcity in local EO research, some academics might still discern a problematic implication of "Western standards as the benchmark" in local EO research (see for example Escobar, 2011). Though only considered in theory, this paper discusses that not acknowledging local agency towards such a benchmark, in parts of the world, might actually constitute another misrepresentation of countering collective experiences of the colonial past.

Overall, this paper also describes a postcolonial *symmetry*, where different places have a collective imprint of *agency* that is directed towards participation in a global EO arena. This research hence supports any call for addressing the occasional "provincialism prevailing among western scientific gatekeepers, their sense of the limits of the 'normal' scientific community, and their fixed expectations of those who lie beyond it", as Abraham phrases it (Abraham, 2006:214–215). Scientific gatekeepers then comprise those in the social sciences who provincialise specific global communities of practice at too many levels and those in EO research, who focus on self-referential activities in the Global North. It, however, also comprises those who proactively engage with transnational EO communities of practice but do yet rely on static models of assessing local capacities. For example, 39 years ago, when Gall (1983) suggested to critically assess the transfer of space science and technologies to developing countries, she mentioned experiences with the training of "lower level Third World technicians" from West Africa. Acknowledging that Gall wrote from a southern standpoint 39 years ago (National Autonomous University of Mexico), this research does not confirm a then-stated local "lack of insight into the relevance of the space technology" (Gall, 1983:7).

Though the infrastructural aspect does indeed constitute a challenge, this research suggests that a wider EO policy arena still often reduces EO research to developmental issues in terms of institutional capacities and technical issues, such as research output. The careful experience-based integration of EO in Earth sciences and also the independent agency of knowledge brokering and down-to-earth capacity building do not dovetail with related models, such as a nation's climbing of the space technology ladder (Wood and Weigel, 2012). Despite *space science* being spellbinding for also many local researchers, if EO is primarily treated as part of this overriding category in the context of technology and knowledge transfer, it might indeed be a static modernisation narrative that is disguised by "development jargon" (Sillitoe, 2002:109). Accordingly, by looking at how EO researchers purposefully participate in different communities of practice, STS at the intersection of anthropology and developmental geography can help in amending overly broad developmental agendas that might otherwise misrepresent actual research goals in the Global South (Schurr and Verne, 2017).

There actually is a promising transdisciplinary future appearing on the horizon to identifying such co-occurring "geopolitical asymmetries" and symmetries. For example, Hofmänner and Macamo (2021) look at how science policy in Switzerland is about to expand "international scientific cooperation and science diplomacy" to the Global South beyond previous "development cooperation". However, the normative standards that construct "international scientific cooperation" are not yet sufficiently questioned. They overlook the range of CoP-related objectives, established institutional scientific work, processes across national borders, infrastructures, the tools used and an understanding of what might actually be achieved (Hofmänner and Macamo, 2021). More empirical studies are needed in this respect to allow for a collective agency in relation to global challenges.

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