Geogr. Helv., 72, 17–27, 2017
www.geogr-helv.net/72/17/2017/
doi:10.5194/gh-72-17-2017

+ GEOGRAPHICA HELVETICA + supported by sc|nat

Drones for justice: inclusive technology and river-related action research along the Kapuas

Irendra Radjawali and Oliver Pye

Department of Southeast Asian Studies, Bonn University, Bonn, 53113, Germany

Correspondence to: Oliver Pye (oliver.pye@uni-bonn.de)

Received: 2 February 2016 – Revised: 31 October 2016 – Accepted: 19 December 2016 – Published: 17 January 2017

Abstract. This article discusses the potential of using drones for community-based counter-mapping. Drawing on action research conducted along the Kapuas River in West Kalimantan, Indonesia, we describe how drones were used for political interventions against land grabs by palm oil and mining companies. We share our experience of how to use drones to generate high-resolution aerial photographs that can be stitched together to create GPS-referenced maps that can support local communities' land rights. We argue that do-it-yourself drones can reduce the costs of and expertise hitherto associated with counter-mapping. While this creates the potential for a more inclusive technology, the question of who controls the technology and to what end is a political one. We conclude by comparing two interventions and discuss why the drone technology could be appropriated by local activists in one case but not in the other.

1 Introduction

This article discusses the potential of using drones, or unmanned aircraft vehicles (UAVs), for community-based counter-mapping. Drones have become notorious over recent years as "weapons of mass destruction," responsible for the death of thousands of civilians (Cockburn, 2015; Cohn, 2015). But is it possible to appropriate this technology and to use it for completely different goals, as a tool for environmental and social justice? We argue that it is.

The findings are based on an action research project on the political ecology of the Kapuas River, in West Kalimantan, Indonesia (2011–2015). The Kapuas River is the longest river in Indonesia. Emerging from the central mountain range of Borneo, it is fed by streams and tributaries from the still forested mountains of Kapuas Hulu. In the rainy season, much of its overflow empties out into the lakes and swamp forests of the Kapuas Lakes, home to a high diversity of fish, bird and animal species. By the time the river reaches Putussibau (900 km inland) it becomes a muddy, slow-moving river connected to countless swamps and oxbow lakes that are created when a meandering arm is cut off from the main source over time. The size of the river and its interconnectedness with this system of forests, swamps and lakes have created immense ecological diversity, which is the source of livelihood for the people there (MacKinnon et al., 1996).

In recent decades, however, the river and the province of West Kalimantan have seen enormous economic, social and ecological transformations. Widespread logging in the 1980s and 1990s has been eclipsed by rapid conversion of forested areas into palm oil and wood pulp plantations (Potter, 2008). Small-scale to medium-sized gold mining activities are ubiquitous along the river's tributaries (Peluso, 2015), while large-scale coal and bauxite mining operations are spreading rapidly. In the upper reaches of the river, various conservation programs including national parks and REDD+ projects are imposing different regimes of resource control upon the local populations (Eilenberg, 2015).

These socio-ecological transformations in West Kalimantan are being implemented and enforced with the help of spatial planning and mapping. National, provincial and district governments that follow a development strategy of attracting foreign direct investment use mapping to impose their right to rent out large areas of land to investors, and this is encoded in spatial plans (Lembaga Gemawan and Indonesian Corruption Watch, 2013). State mapping activities and their access to geographical information "facilitates large-scale accumulation strategies" and "consolidates state control" (Peluso, 1995:383). In Kalimantan, spatial planning has

carved up most of the province into spatially defined categories of protected forest, productive forest, conversion forest, mining and local use. Often, the people living in the areas that are classified in this way are not consulted and have no idea that land that they use and view as theirs by customary law is being classified and sold off by way of mapping.

In response to this use of mapping technology for state and capital territorializations, a movement has developed that uses counter-mapping "to appropriate the state's *techniques* and *manner of representation* to bolster the legitimacy of "customary' claims to resources" (Peluso, 1995:384, italics in original). In the 2 years leading up to the passing of a new spatial planning regulation, the Provincial Regulation on Spatial Plan Documents (RTRW) of West Kalimantan (2015) and West Kalimantan NGOs joined forces to create the Civil Society Coalition for a Just and Sustainable Spatial Plan in West Kalimantan in order to intervene in the process and to anchor local rights and participation within the new legislation (Lembaga Gemawan and Indonesian Corruption Watch, 2013). In this context, we introduced the drone as a way of producing high-quality counter-maps to counter state and corporate claims to land and to legitimize local claims. Our argument is that technical advances have made this kind of technology more accessible to local communities and that drones could revolutionize the counter-mapping movement by placing high-resolution and geo-referenced spatial data in the hands of the grassroots. In this spirit, this article shares our experience of using drones for counter-mapping, and we hope that this can be shared widely and improved upon.

The question of using drones for emancipatory purposes is more than one of reducing costs. If mapping by the state is enthused with categorizing power connected to the representation and production of space (Harley, 1989), then so too must the counter-mapping movement ask who controls the production of these counter-maps, who fills them with meaning, and how mapping technology and activities change relations of power, gender and knowledge production within the participating community (Parker, 2006). Introducing drones in counter-mapping activities can end up repeating mistakes and ambiguities associated with previous counter-mapping movements (Bryan, 2011). So far, advances in civilian drone technology have been made in the context of humanitarian crisis intervention (Sandvik and Lohne, 2014) and in environmental surveillance (Watts et al., 2010), which is usually NGO-led spatial control, albeit in the interests of biodiversity conservation. So, for example, Koh and Wich (2012) pursue an exclusively technical discussion of the use of drones to monitor land use changes and neglect entirely questions of environmental justice and who is able to use this technology and to what end. The issue here is whether the increasing popularity of non-military use of drones represents only a shift towards civilian technical surveillance of various shades or whether drones could also become an inclusive technology for grassroots activists and for emancipatory purposes?

The first part of the article discusses how drones could contribute to the counter-mapping movement by addressing some of these problems and, therefore, places the development of the "community drone" within the method of action research that informed our exploration of the political ecology of the Kapuas River. In the following sections, we discuss the social and political dynamics of introducing drone technology into a conflict over palm oil and into communities impacted by bauxite mining. We then show how the combination of action research and politicized drone use led to an explosion of interest across Indonesia in the drone as a counter-mapping tool and also to some successful political interventions.

2 Counter-mapping dilemmas and drones

Counter-mapping usually refers to the practice by which indigenous communities map their customary or ancestral lands in order to back up legal claims to their territory. As Nancy Peluso put in 1995 (384), the counter-mapping movement appropriates "the state's *techniques* and *manner of representation* to bolster the legitimacy of "customary" claims to resources" (italics in the original). Indigenous people, particularly in North America, started using participatory mapping to fight for the legal recognition of their ancestral lands from the 1970s onwards. Since the 1990s, the counter-mapping movement has spread across the world and has seen their counter-maps recognized by courts and nation states in a series of legal victories (Chapin et al., 2005; Wainright and Bryan, 2009; Bryan, 2011). In Indonesia, a large network of groups and organizations involved in counter-mapping emerged in the early 1990s as movements fighting against large-scale development projects started to campaign for customary rights over land and forests. By 2009, communities active in the Community Mapping Network (Jaringan Kerja Pemetaan Partisipatif, JKPP), in close collaboration with the Alliance of Indigenous Peoples of the Archipelago (AMAN), had mapped 510 territories and 2.5 million ha of land (JKPP, 2009).

Despite its proliferation and popularity as a strategy, however, counter-mapping soon encountered several dilemmas. One of these was related to technology and scale: if the maps were produced as (geo-referenced) sketches (participatory and culturally sensitive), they "could not take on land tenure and legal battles with the state" (Chapin et al., 2005:628). This is the main problem of the counter-mapping movement in Indonesia – despite the intense work of decades and over 2 million ha of land that have been mapped – little has yet been legally acknowledged by the state. If, however, counter-mappers used GIS technology, the resolution of satellite imagery was so low that experts were needed to translate the information into maps that could both communicate to the state and to those on the ground initiating the counter-mapping. GIS technology remains "complex, highly technical, and expensive, especially for rural villagers" and GIS laboratories

"must be bankrolled by international donors" (ibid: 629). This is the basis for Nancy Peluso's assertion that counter-mapping would never become a "science of the masses" (1995:387).

This leads to a second and perhaps more fundamental dilemma. The funding and expertise required for counter-mapping leads to "new types of power relations around the control and knowledge of mapping technologies" (ibid). As Parker (2006) argues, unequal power and gender relations within a geographically defined "community" are amplified or reconfigured by the political and social processes emerging from the introduction of a counter-mapping strategy. In their counter-mapping work with indigenous communities in Belize, Wainright and Bryan observed that women were excluded from participatory mapping exercises because they are "often not seen as bearers of the sort of geographical knowledge that should be mapped to define the community's territory" (2009:161). This leads to a gendered "cartographic portrayal of customary use." The "cartographic–legal strategy" leads to new inequalities and hierarchies, as those community members who work with the legal and cartographic experts come to occupy a more powerful position vis-á-vis other community members. Wainright and Bryan (2009) also show how the cartographic–legal strategy led to "subtle shifts" in strategy, as the leadership of the Maya movement changed to reflect the requirements of negotiating with state structures. In Indonesia, the community mapping network JKPP, on reflecting their own work, noted an obsession with the technicalities of mapping that led to neglect of political strategy (JKPP, 2009).

Furthermore, negotiating boundaries with the state means accepting the latter's legitimacy and its territorialization that is connected to property rights, leading to the territorialization of "previously fluid and not mutually exclusive" claims (ibid 165). This can lead to horizontal disputes between different communities, disputes that can become "cast in terms of *ethnic difference*" (ibid 165) rather than in terms of "local vs. state or corporate" land appropriation. Counter-mapping can thereby "racialize debates over land rights" (Bryan, 2011:45). This is also a problem in the Indonesian context. In West Kalimantan, counter-mapping by indigenous groups led to a "revitalization of Dayak identity" (Pramono et al., 2006:8). Given that Dayak elites had organized communal violence against immigrant farmers of Madurese origin in 1997 (Van Klinken, 2008), an ethnic framing of land conflicts can be problematic. If counter-mapping is organized along racial lines (rather than in terms of class solidarity for land reform for example) it can become a tool for the production of new "racialized territories" (Peluso, 2008).

In their book on the "good drone", Sandvik and Jumbert (2016) discuss the overlaps of military and civilian drones in "the global battlescape, the humanitarian emergency zone, and the field of everyday politics." However, they have not looked closely at the use of drones for counter-mapping. Elsewhere we have developed the argument that the drone represents a technical revolution that can potentially address some of the key problems of counter-mapping (Radjawali et al., 2016). The high quality and high resolution of the aerial photographs contrast with the lower resolution and often outdated information of satellite images. This means that they could be more readily recognized by legal–cartographic state systems. Self-made drones are also more affordable for local NGOs or community organizations, reducing dependency on donor organizations. Less expertise is needed to fly the drones and to produce and interpret the maps compared to the GIS-based analysis of satellite images. This can potentially reduce the hierarchy of knowledge and power accumulated in the hands of technical and legal experts. Because maps can be produced on a laptop very soon after the drone flight, local people can be more actively involved in discussing the information contained in the aerial photographs. Ideally, a fairly large number of people can be involved in identifying which areas to map and why, in operating the drone or at least witnessing its flight and in analysing the map within a period of a few days.

For these reasons, drones are currently revolutionizing the counter-mapping movement. Since Irendra Radjawali introduced the drone in our project on the Kapuas River, he has been contacted by hundreds of activists and organizations in Indonesia and as far afield as Guatemala and Brazil, asking him to show them how to build and operate drones for counter-mapping purposes (see Radjawali et al., 2017). However, the drone technology as such does not solve the political problems of territorialization connected to the "legal–cartographic strategy" sketched above. Its exciting technological potential also makes it susceptible to prioritizing the technical over the political. In her discussion of development in Indonesia, Li (2007) analyses how political struggles over access, rights and power were marginalized by the "rendering technical" of the dominant (neoliberal) poverty reduction development strategy. In a similar way, the use of drones could perpetuate the problem of depoliticizing social struggles over land into a technical exercise of (improved) mapping and legal recognition.

3 Rendering political: the drone project

In our project, we attempted to counter a "rendering technical" of drone technology by "rendering political" the appropriation of a technology of control for community empowerment. Our starting point was neither counter-mapping as such nor a focus on territoriality but rather a spatially informed analysis of the socio-ecological transformation of the Kapuas River. We followed a political ecology approach – looking at the production of nature, actors, power relations, discourses and political struggles and conflicts (Robbins, 2004) – to the transformations impacting the river and their socio-ecological interactions with society. Spatially, we rejected currently hegemonic concepts of river basin management that "see river basins as rational units" and that strive

to optimize the management of the river basin by technical expertise and improved coordination between manifold institutions located upstream and downstream (Molle, 2007:358). A conceptual exclusivity to territorial spatiality (i.e. the river basin as a bounded, physical space) neglects other spatialities of power and resource flows that are created by interactions between territory, place, networks and scale (Jessop et al., 2008). As Molle (2007:359) notes, "many causes of water-related problems as well as their solutions may indeed lie outside river basin boundaries". Instead, we adopted an approach that looked at how different city–hinterland–river transformation loops involved different economic, social and ecological dynamics at different scales, in distinct networks and involving specific places (Pye et al., 2017).

To this end, we identified key transformation processes that were connected to and impacted the political ecology of the river in different ways. Some of these (the river as a site of social reproduction, gold mining, fisheries) are directly connected to the river as a flowing body of water, while others (expansion of palm oil plantations, conservation projects, logging, bauxite mining) impact adjoining landscapes and so impact the riverine ecological system as a whole. All these transformations have direct impacts on the ecology of the river. Upstream, conservation initiatives are undermined by the degradation and conversion of tropical forests that jeopardizes the biodiversity of the river system, while palm oil mill effluent (POME), an organic pollutant, is dumped in Kapuas tributaries. Fishermen react to the resulting declining wild fish stocks by investing more into aquaculture, which, because it relies on catching fish fry, exacerbates the decline in fish stocks. Gold mining, with its use of mercury for amalgamating the gold, contaminates water and fish downstream (Pye et al., 2017).

To understand the social and political dynamics connected to these environmental changes, we selected seven places to start our enquiry into the territories, networks and scales of these transformation loops. This is where we developed the concept of participatory hydro-political appraisals (PHPAs) that were transdisciplinary (Lang et al., 2012) and that added an action research element to the project. Action research seeks to "form partnerships with community members to identify issues of local importance, ways of studying them, collect and interpret data, and take action on the resulting knowledge" (Smith et al., 2010:407–408). In this sense, drones were an instrument to be used by community activists in order to produce maps for objectives identified in a collaborative research process.

Each PHPA consisted of seven interrelated steps that started with a reconnaissance and grouping exercise in which we introduced the project to the group/community and the setting up of a citizens research group (CRG) with whom we then discussed the research plan and the idea of connecting up with other communities along the Kapuas and its tributaries. In this way, we hoped our research would become a jointly owned process of "social learning" (Buchy and Ahmed, 2007). We continued with a series of "place biography narratives" exploring the history and changes to the place and the river and with a "river transect," i.e. a trip by boat up and down the river to identify key issues, problems and changes. The heart of the PHPA consisted of a series of group discussions, i.e. the "spatial problem analysis", "change objectives" and the "spatial intervention analysis" (Fig. 1). The idea was to discuss perceived problem and key actors (affected by and responsible for) and to locate these in sketches where the village or place of the PHPA was related via the river to other nodes of relevance (Fig. 2). The line of enquiry was then determined by key change objectives identified by different groups (women-only group, youth group, men's group, etc.) and by potential interventions that could be followed up by the community itself.

Drones were introduced by Irendra Radjawali in two of these PHPAs, where counter-mapping was seen as a potential intervention. Instead of a narrow focus on counter-mapping for indigenous territorial claims, the drones were

Figure 1. A group discussion with the women's group in Tayan.

Figure 2. Spatial problem and intervention analysis. Key issues and interventions identified by the citizen research group were related spatially to the river.

deployed in the sense of a broader understanding of "critical cartography" by which "social movements employ spatial and cartographic knowledges in order to analyse and transform existing spaces and prefigure alternative ones" (Cobarrubias and Casas-Cortes, 2009:339). In the first case we discuss, small-scale farmers near Sintang used the drone technology to counter their criminalization by a palm oil company. They could show that the company – a member of the Roundtable on Sustainable Palm Oil (RSPO; see Pye, 2016) – had encroached upon customary land and had breached requirements not to plant along river banks. In the second case, communities impacted by a large bauxite mining operation in Tayan in the lower reaches of the Kapuas decided to use drones for four different purposes. Firstly, one hamlet wanted to use aerial photographs to prove that their area was inhabited and to challenge the status of their land as "forest land". The land classification by the spatial planning agency had used satellite images that had "erased" the people's dwellings. A second village wanted to map their customary fruit tree forest in order to get it recognized as a customary forest by the forestry department. Thirdly, villagers wanted to take aerial photographs of a wetland area jeopardized by pollution from a rubber company and from bauxite tailings, an area that they plan to use as a destination for ecotourism. A fourth intervention was to use drone-produced images to prove that the bauxite mining operation had extended beyond the concession area and that the company had laid an oxbow lake completely dry by diverting a Kapuas tributary. The politicization of the latter case went far beyond the local issue when evidence provided by the community drone images was used in an NGO intervention into the provincial spatial planning process and when a Tayan community representative gave testimony to the Constitutional Court in a hearing on Indonesian national mining policy that was being challenged by multinational mining corporations.

We first introduced drones into our project after physical access to the bauxite mining site was denied by company security guards. We were looking for a way to create aerial photos of the area, and drones seemed to be one possibility. Without prior experience, we had to develop the drones from scratch and, without funding to pay for ready-made drones, we also had to keep costs down. The result of this trial and error process was that we managed to build and operate a drone for around USD 500. At this price, drones for countermapping have the potential of becoming a "science of the masses" (Radjawali and Pye, 2015). However, the question of who controls the drone and the maps remains.

4 Mapping palm-oil-related land conflicts

In Indonesia and in West Kalimantan in particular, palm oil expansion is one of the main causes of land conflicts and environmental destruction (Pye and Bhattacharya, 2012). When companies are awarded concession permits to establish oil palm plantations, communities with customary land that is not acknowledged by the state and local farmers who have no official land titles find themselves in a weak position to assert their land rights. However, after obtaining a permit, the palm oil company must secure permission from local land owners for at least 50 % of their total concession area within 2 years. Otherwise, their permit will be withdrawn by the local government and can be given to another company. This opens up the possibility for communities to resist the expansion of palm oil into their area. In practice, however, companies are often able to win over local leaders and individual farmers with the promise of development (e.g. roads) and higher incomes. Most expansion areas are therefore characterized by messy "horizontal" conflicts within local communities, with some supporting and others rejecting palm oil.

In our action research location, in Ketungau Hilir subdistrict, Sintang Regency, these dynamics created a complicated situation. The palm oil company, a subsidiary of Triputra Agro Persada, a RSPO member with a track record of deforestation, peatland conversion and social conflicts (Chain Reaction Research, 2015), was granted a concession for 20 000 ha and succeeded in gaining approval from the village head and the customary council. However, not all local farmers gave permission to the company to use their land for the oil palm plantation. The action research with the CRG revealed serious environmental problems that were impacting the daily lives of the farmers. Wetlands, important for subsistence fishing, had been drained. The polluted drainage canals were no substitute for the loss of clean water sources and locals now had to bring in bought water by motorcycle into their area. Farming for both rice and vegetables became difficult because of the changed hydrology and because of pesticide run-off. In addition, members of the CRG had seen their land taken by the company. In one case, 100 ha claimed and farmed by one family had been converted into palm oil and no compensation had been given. The company just cleared the land and cut down rubber trees that they had planted. The farmer could not really do much about it as he had no official land title to prove that it was his land. Two other members of the CRG had been criminalized by the company after they had pulled out the seedlings that the company had planted on their land. They were put in prison for 1 month and 12 days without trial.

In this context, the CRG thought that mapping their area could help to establish proof of company violations to support their resistance as well as to go further for possible legal actions. We used drones to map two conflicting areas. The first area was the 100 ha of farmland and rubber that had been taken by the company mentioned above (Fig. 3). We were able to map only about 30 ha of the area due to the bad weather (hard rain) and due to security reasons (threats by company staff and surveillance by local police). We lost one drone and a mapping camera as the drone crashed due to battery failure. We were able to find the drone and analyse the cause of this fall. The photograph shows cleared land

Figure 3. Drone-produced orthophoto showing palm oil planted on local farmland, rubber gardens and customary forest.

Figure 4. Drone-produced orthophoto showing the drained swamp forest lake Danau Meradung and the enclaved cemetery forest.

recently planted with oil palm and enclaves left out of the conversion. The land south of the horizontal transect road is claimed by the family, while the land north of the road was customary forest released to the company by the customary council leaders. In the northwestern corner, a site was being prepared for a palm oil factory that has recently been opened by the head of the district. The photo is actually a high-resolution and georeferenced orthophoto which can be zoomed into for more detail. The CRG hopes that it can be used to claim back the land or to obtain reasonable compensation.

The second area was about 30 ha and previously a wetland swamp (Danau Meradung) and a customary cemetery forest (Fig. 4). The area was drained and turned into an oil palm plantations. The company also left part of the cemetery forest as an enclave inside the plantation. Several influential community members gave permission to clear the land without consulting the others, leading to dissatisfaction within the wider community. CRG members and other locals accompanied us to the area and thought that a drone map would be beneficial for their struggle in the future. The orthophotograph shows the extent of the draining canals in the centre, as well as new plantations and roads and the cemetery forest enclave. It also shows planting right up to river banks, which contravenes both RSPO criteria and Indonesian law.

Our work in Ketungau Hilir showed that drones can be useful for mapping palm-oil-related conflicts. The high resolution of the aerial photographs and the relatively easy (open-source) software for stitching the photographs together to produce a map make drones ideal for capturing detailed landscape information. However, in this case, the appropriation of the drone technology by grassroots activists was limited. Members of the CRG were actively involved in deciding why and where the drones flew and in flying the drone (Fig. 5). In this sense, the orthophotos were co-produced because they developed from the biographies and perspectives of the local activists themselves. However, the local group did not appropriate the stitched maps or the drone technology. One problem was the remote location (8 h motorcycle trip along dirt roads) and the marginalization of the community involved (no electricity). The lack of electricity not only was responsible for the drone crash but also prevented us from stitching the images to create an orthophoto map in situ. These maps could only be created after we returned back to the city of Sintang where we had access to electricity some days later. Local activists were not able to fly the drone, then stitch pho-

Figure 5. Flying the drone with the citizen research group in Kentungau Hilir.

tographs and discuss the map directly, and thus a key empowering moment of the drone technology was lost.

The main political problem was the political rift within the community itself. It was not just that the corporation has immense economic and political power in these remoter regions of the palm oil frontier but that political representatives at the local level actively supported the company. The group of farmers in the CRG was politically marginalized in the face of an alliance between local leaders, company management and local police and courts. This meant that we had to meet clandestinely, making it difficult to conduct open training on how to use the drone. Politically, this also prevented a unified strategy at the local level that could use the drone maps against the land grab by the company.

Our intervention in Ketungau Hilir was conducted in cooperation with the Front Aliansi Masyarakat Korban Investasi (FAMKI), a local Sintang people's organization that organizes local communities in struggles against land grabs. We hoped that by linking up with FAMKI, the CRG could develop a strategy to resist the land grab. While discussing the follow-up of the action research, however, it became clear that FAMKI was too fragmented and had too limited financial capabilities. FAMKI members were only able to travel to Ketungau Hilir because the cost had been covered by our research project, so the follow-up of drone mapping activities had to be postponed until they had secured more financial support. This meant that local activists have not become drone builders and operators. We could discuss the maps with FAMKI in Sintang and they were enthusiastic about the potential use for their work, especially because of the quality and precision of the data and the speed in which large areas could be mapped. Previously they had relied on GPS tracking, a method that requires much more time. So far, the Ketungau Hilir drone maps have only been used as preliminary data for analysis by NGOs in Pontianak. This was useful to support their advocacy for protecting community managed land to be recognized by government at the spatial planning processes. The map has been used as one field evidence of how encroachment happened. Narratives have been built around the map and the PHPA processes. Nevertheless, the maps were not appropriated by the local activists themselves, but rather by NGOs in the city.

5 Challenging a mining company

Another major industry in West Kalimantan with severe impacts ecological impacts on the river is the mining industry. Our research location, Tayan Hilir in Sanggau Regency, is in an area where a large number of companies mine bauxite. Large quantities of water are used to wash the bauxite deposits, and the bauxite tailings ("red mud") are flushed into the river. In Tayan Hilir the mining company PT. Mahkota Karya Utama (MKU) obtained their permit in 2009 to exploit the area. Apart from the deforestation that accompanies the huge open pit mining sites, pollution of the rivers is a major concern. In particular, fish stocks have plummeted – formerly a key source of livelihood in this wetland area. In Tayan Hilir, the company had drained the Semunduk lake, formerly an important fishing ground, and used it as a dump site for bauxite tailings.

Opposition to the mining companies was much more cohesive than in the Sintang case, and leaders from the customary council supported the action research. A citizen research group made up of men and women and from different ethnicities played an active role throughout the process. With the help of our partner, the Swandiri Institute, based in Pontianak, we set up a "drone school" in order to train locals how to fly the drone and how to use the software to stitch the orthophotographs together. About 25 people from different ethnic groups, including members of the customary council but mainly younger, technophilic men, took part in the training. The CRG organized larger meetings where the goals of the research and the areas to be mapped were discussed and decided. Flying the drones was quite an event, with lots of onlookers, curious children and questions. The CRG also ensured that many locals took part in a meeting that discussed the aerial photographs after they had been stitched together as maps.

During the river transect exercise, we prepared the drones to map the drained lake. CRG members and other members of the community were trained to set up the flight mission in Mission Planner (Fig. 6). We used a tricopter drone as the area to be mapped was not too large. The mapping took about 30 min and we were able to capture around 30 ha of the drained and polluted lake. CRG and community members were able to observe and to learn about the whole process of using drones to map an area, from creating the mission to the operation of the drones. The drones was flown at the altitude of 350 m a.g.l., which gave us images with the ground resolution of about 12 cm (Fig. 7). The drone images could show that the mining company was operating outside its concession area (the grey overlay). The devastated lake at the

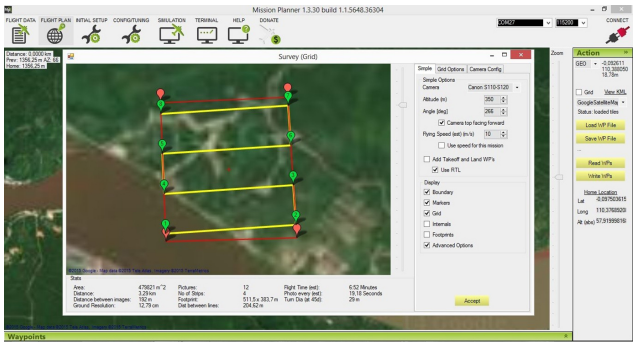

Figure 6. A flight mission prepared by the citizen research group in Tayan.

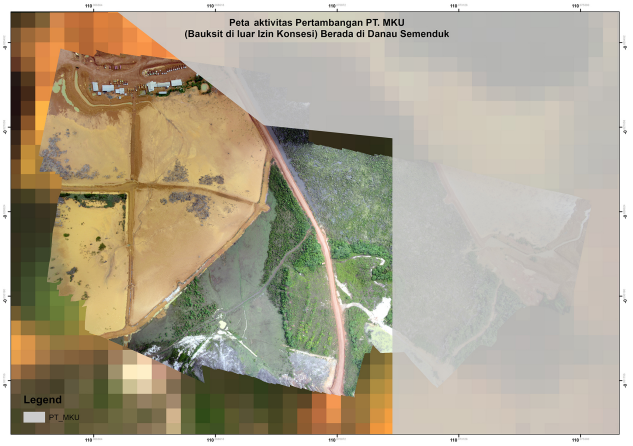

Figure 7. Drone orthophoto showing the drained Semunduk lake area and the bauxite mining concession (grey).

left of the picture has become a dry desert compared to the (polluted) wetland area below. After stitching, local activists were able to zoom into the picture and were able to identify individual trees, company trucks and further details.

With the active involvement of local activists, the Tayan case was taken up by our local partners Swandiri Institute and Lembaga GEMAWAN, two Pontianak-based NGOs, to support their advocacy work towards more just and sustainable spatial plan in West Kalimantan. In September 2014, the Civil Society Coalition Towards a Just and Sustainable Spatial Plan, of which Swandiri Institute and Lembaga GEMAWAN are members, was invited by the provincial government of West Kalimantan to discuss the District Regulation on Spatial Planning. Lembaga GEMAWAN and Indonesian Corruption Watch (2013) argued that the District Regulation on Spatial Planning had not been able to cope with several problems related to spatial allocations in West Kalimantan Province, such as (1) the existence of settlements inside the forest area, (2) social forests including community-managed forests, village forests and customary forests that were not recognized in the regulation, (3) recognition of community-managed areas, and (4) mechanisms on the prevention and resolution of conflicts over space. The coalition demanded that the passing of the regulation needed to be postponed until the provincial government dealt with these issues to promote a more just and sustainable spatial plan. When the provincial government demanded evidence, Swandiri Institute and Lembaga Gemawan used the map of the drained lake to support their argument that there are still unresolved conflicts as well as illegal operations of extractive industries activities in West Kalimantan that need to be tackled. All the coalition's demands related to the promotion of a more just and sustainable spatial plan were accepted.

In a related intervention, the same orthophotograph was used by a member of the Tayan community to give testimony before the Constitutional Court that was reviewing the challenge by large mining corporations to the 2009 National Mining Law. The court invited testimonies by local communities impacted by mining in order to decide whether the stipulation requiring mining companies to install further processing facilities should be upheld or not. In 2014, the court ruled against the mining corporations, upholding the 2009 law. The fact that the Constitutional Court accepted a map produced by local activists with a drone as evidence created a legal precedent, which suggests that drone counter-maps could be recognized by the Indonesian legal system more often in the future. This decision and the evidence presented also prompted the Ministry of Energy and Mining Resources to review existing mining concessions. The Swandiri Institute used drone-produced orthophotographs to show that several mining operations had been operating illegally in West Kalimantan, and these were subsequently shut down, including the mine in Tayan Hilir (Eyes On The Forest Jaringan Kalimantan Barat, 2016).

In the Tayan case, community activists have learnt how to build and operate drones and how to use drone images for political objectives. Drones were used inclusively to support participatory mapping and became a tool for advocacy around spatial planning. The work of local community members and Swandiri Institute has generated interest not only at the national level but also at the international level. The work has been covered by the media, increasing the awareness of the need for reliable, accessible and accountable spatial data for the promotion of more just and sustainable spatial planning. Developing a more general narrative, Swandiri Institute has been promoting what they call "inclusive technology for just and sustainable spatial planning", in which drones play a key role (Swandiri Institute, 2014).

Swandiri Institute and local community members are still working on mapping community-managed land and customary land in Tayan. They have two targets to further politicize their work with drone maps. The first goal is to register their maps with the One Map Indonesia Policy through BRWA (Badan Registrasi Wilayah Adat/Customary Territory Registration Body), a non-governmental body formed by several NGOs with the aim of consolidating the data and information

on customary territories that have been mapped (Radjawali et al., 2016). The second objective is to promote the District Regulation on Customary Forest as the legal umbrella for the protection of customary land in Sanggau District. Another strategy that the local community and Swandiri Institute will take is through the opportunity of the recently passed Village Law (law no. 6/2015), in which villages are given more authority to manage their territory and their socio-economic affairs. At the village level, the local activists are now promoting the village customary areas organization with the aim of promoting collective action and management of their areas. Drones ares seen as a technology that is inclusive and liberating, and the decision to use them was a collective decision. The maps made by the drone became collective maps.

Perhaps the most important development in promoting drones as an inclusive and emancipatory technology has been the creation of a "drone school" in Pontianak by Swandiri Institute. The objectives are threefold: (1) to train drone pilots, (2) to train local activists how to use the drones for supporting participatory mapping of community-managed and customary areas, and (3) to provide high-resolution, georeferenced and accessible data to support the advocacy work of NGOs and communities in West Kalimantan and in Indonesia. Swandiri Institute has been able to train several local community members in Tayan to be drone pilots as well as to train some NGO activists in West Kalimantan and in Papua to use drones for mapping forest areas. Together with Publish What You Pay Indonesia, the institute has also conducted courses for organizations working on the issues of transparency in extractive industries. The drone school is intended as a programme for learning to build and to operate drones for mapping as well as to perform post-processing activities to produce maps. However, the technical training is embedded in education on the legal and political context and opportunities for action on promoting local community land rights. The main aim of the drone school is to support the political activism of NGOs and local community members through the provision of good quality data.

6 Conclusion

The development of affordable drones creates the potential for grassroots activists to appropriate technology as a tool for social and environmental justice. Drones are no longer the exclusive property of the military or of financially powerful actors. An expanding do-it-yourself drone community, low-cost UAVs and cameras as well as open-source software all mean that it is now possible to put drones in the hands of grassroots activists. The high-resolution images that can be produced by drones can be a powerful tool to challenge spatial planning and maps that have traditionally been controlled by state and corporate interests. In a world where corporate land grabbing is leading to land conflicts and environmental destruction in the Global South, we expect that drones will increasingly become a "weapon of the weak" to fight for a more just and inclusive spatial planning.

The use of drones in action research on the Kapuas River shows that counter-mapping can be used for a variety of purposes and not only for mapping territorial claims. The detail in the aerial photograph maps is so great that socio-ecological dynamics can be captured. The grabbing of land of individual families, the draining of wetlands, operations outside of allocated concession areas, customary forests, etc. can all be mapped with drones, leading to different kinds of campaigns for environmental justice. Academics at UNTAN University in Pontianak, for example, have started to develop a drone that uses infrared cameras to document organic pollutants in the Kapuas River. This could become a tool for campaigning around pollution by POME discharges into river systems. The example in Tayan also shows that counter-mapping does not necessarily lead to racialized claims: Dayak and Malay farmers joined together to campaign against the destruction of the Semunduk lake by the bauxite mining company.

In our action research on the Kapuas River, the use of drones was still very localized. Due to temporal and financial constraints, we were unable to use drones in all of our PHPA sites and to scale up and connect our counter-mapping to capture the spatial dynamics of networks and scales that characterize the flows of investment, power, corruption and pollution that define the socio-ecological transformation of the river. However, the Swandiri Institute expanded their work with drones across West Kalimantan in order to push for a more just and inclusive spatial planning process. As more local activists are trained in the building and deployment of drones and in the analysis and political use of the counter-maps, they can increasingly use the opportunities now in place as a result of this campaigning.

Whether civilian drones will be used in this way is foremostly a political question. The proliferation of drones as a hobby, for commercial mapping services and for surveillance purposes shows that there is no automatism linking technology to emancipatory aims. In their discussion of the "good drone", Sandvik and Jumbert (2016) show that there is a lot of overlap between military use of drones and civilian surveillance projects. In environmental politics, the question of who controls the drones and to what end is particularly important. While the use of drones to monitor forests and to combat illegal logging might seem benevolent and politically neutral, it really depends on the political ecology context in which this happens. In Indonesia, placing drone surveillance technology in the hands of the forestry department, which legalizes large-scale corporate logging whilst criminalizing local "illegal" logging, would most likely cement existing power structures and would not challenge the structures facilitating the logging of natural forests. Placing drones in the hands of local forest-based communities would be a different political project.

Our aspiration in using drones was not only to produce high-resolution orthophotographs that could be used by local communities in their struggles for environmental and social justice. We also hoped that the drone technology could be appropriated by local activists themselves and have an empowering and liberating effect. In theory, this should be achieved by integrating drones into action research, where they can support citizen research groups in co-producing "their own knowledge, with their own biographies, explanations and applications (Conde, 2014:69). In practice, this is more difficult to achieve, as our two examples show. Active involvement in building and operating drones and in using the results to develop and follow through political strategies varied considerably as a result of technical, financial and geographical constraints. Most importantly, the concrete political context of the drone-related action research in the specific locality and the connection to wider networks were crucial.

As we have seen, the goal of an inclusive drone technology in the hands of communities is not so straightforward to achieve. To start with, "communities" are not homogenous entities fighting for local control vs. corporate interests. Rather, they are politicized and divided along social, political and gender lines and embedded within larger transformation networks (Waylen et al., 2013). If "maps *emerge in process* through a diverse set of practices" (Kitchin and Dodge, 2007:340), any initiative that aims to introduce drone-based participatory mapping must decide on who to include, who to exclude and whether to accept or challenge localized power structures. If researchers include drones in their work, they need to develop strategies that prevent a hit-and-run kind of intervention, where the technology and the maps produced remain or end up under the exclusive control of the research institution (Buchy and Ahmed, 2007). We have argued that an action research approach can overcome this problem, but that it needs follow-up support by local NGOs and social movements to succeed. Apart from financial and logistical challenges, particularly in remote areas, this can lead to NGOs appropriating the technology and the data rather than the grassroots.

A promising initiative to develop an explicitly inclusive and emancipatory approach can be seen in the founding of the drone school by Swandiri Institute in Pontianak. The school trains local activists to build and operate their own drones and to then process and use the data for collectively developed political strategies. Locating the mission planning in the locality is a concrete opportunity for community involvement in deciding what and why to map. Stitching the images into orthophotos on site is also an inclusive step, leading to broader discussions on interpretation when the results are shown and shared. When local activists create their own high-resolution images and can use their own maps to negotiate eye to eye with government or corporate representatives, drones can contribute to an empowering process of self emancipation.

7 Data availability

Due to the sensitive nature of the research topic and the social and political conflicts involved, we need to protect the citizen research groups involved in the project. For this reason, we have decided not to make the recordings and transcripts of the PHPA exercises publicly available.

Acknowledgement. Thanks to the German Research Foundation for funding the research project, to UNTAN and the Swandiri Institute for their help and cooperation, and to the citizen research groups that participated in the project.

Edited by: F. Klauser
Reviewed by: two anonymous referees

References

Bryan, J.: Walking the line: Participatory mapping, indigenous rights, and neoliberalism, Geoforum, 42, 40–50, doi:10.1016/j.geoforum.2010.09.001, 2011.

Buchy, M. and Ahmed, S.: Social Learning, academics and NGOs: Can the collaborative formula work?, Action Research, 5, 358–377, doi:10.1177/1476750307083712, 2007.

Chain Reaction Research: Report on Triputra Agro Persada, available at: https://chainreactionresearch.files.wordpress.com/2015/05/triputra-agro-persada-crr-report.pdf (last access: 9 January 2017), 2015.

Chapin, M., Lamb, Z., and Threlkeld, B.: Mapping Indigenous Lands, Cult. Anthropol. 34, 619–638, 2005.

Cobarrubias, S. and Casas-Cortes, M.: Activist cartography: enabling alternative political spaces, Polit. Geogr., 28, 338–342, 2009.

Cockburn, A.: Kill chain. The rise of the high-tech assassins, Henry Holt and Company, New York, USA, 2015.

Cohn, M.: Drones and targeted killing. Legal, moral, and geopolitical issues, Olive Branch Press, Northampton MA, USA, 2015.

Conde, M.: Activism mobilising science, Ecol. Econ., 105, 67–77, doi:10.1016/j.ecolecon.2014.05.012, 2014.

Eilenberg, M.: Shades of green and REDD: Local and global contestations over the value of forest versus plantation development on the Indonesian forest frontier, Asia Pac. Viewp., 56, 48–61, 2015.

Eyes On The Forest Jaringan Kalimantan Barat: Berlindung di balik selimut CnC: Laporan monitoring IUP Minerba di Kalimantan Barat, 2016.

Harley, J. B.: Deconstructing the Map, Cartographica: The International Journal for Geographic Information and Geovisualization, 26, 1–20, doi:10.3138/E635-7827-1757-9T53, 1989.

Jessop, B., Brenner, N., and Jones, M.: Theorizing sociospatial relations, Environ. Plann. D, 26, 389–401, 2008.

JKPP: Menuju Demokratisasi Pemetaan: Refleksi Gerakan Pemetaan Partisipatif di Indonesia, Bogor, 2009.

Kitchin, R. and Dodge, M.: Rethinking maps, Prog. Hum. Geog., 31, 331–344, doi:10.1177/0309132507077082, 2007.

Koh, L. P. and Wich, S. A.: Dawn of drone ecology: low-cost autonomous aerial vehicles for conservation, Tropical Conservation Science, 5, 121–132, 2012.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., and Thomas, C. J.: Transdisciplinary research in sustainability science: practice, principles, and challenges, Sustain. Sci., 7, Issue 1 Supplement, 25–43, 2012.

Lembaga Gemawan and Indonesia Corruption Watch: Public Review. Rancangan Peraturan Daerah. Rencana Tata Ruang WilayahProvinsi Kalimantan Barat, Lembaga Gemawan – Indonesia Corruption Watch, Pontianak, Indonesia, 2013.

Li, T. M.: The Will to Improve: Governmentality, Development, and the Practice of Politics, Duke University Press, Durham, USA, 2007.

MacKinnon, K., Hatta, G., Halim, H., and Mangalik, A.: The Ecology of Kalimantan, Periplus Editions, Hong Kong, 1996.

Molle, F.: Scales and power in river basin management: the Chao Phraya River in Thailand, Geogr. J., 173, 358–373, 2007.

Parker, B.: Constructing Community Through Maps? Power and Praxis in Community Mapping, Prof. Geogr., 58, 470–484, doi:10.1111/j.1467-9272.2006.00583.x, 2006.

Peluso, N.: Whose Woods are these? Counter-mapping forest territories in Kalimantan, Indonesia, Antipode, 274, 383–406, 1995.

Peluso, N.: A political ecology of violence and territory in West Kalimantan, Asia Pac. Viewp., 49, 48–67, 2008.

Peluso, N.: The Gold Farmers, available at: http://asiapacific.anu.edu.au/newmandala/2015/07/17/the-gold-farmers/ (last access: 9 January 2017), 2015.

Potter, L.: Dayak Resistance to Oil Palm Plantations in West Kalimantan, Indonesia, 17th Biennial Conference of the Asian Studies Association of Australia, 1–3 July 2008, Melbourne, Australia, 2008.

Pramono, A. H., Natalia, I., and Janting, Y.: Ten years after: countermapping and the Dayak lands in West Kalimantan, Indonesia (Unpublished report), 2006.

Pye, O.: Deconstructing the Round Table on Sustainable Palm Oil, edited by: Cramb, R. and McCarthy, J.: The Oil Palm Complex: Agrarian Transformation, State Policy, and Environmental Change in Indonesia and Malaysia, 2016.

Pye, O. and Bhattacharya, J.: The Palm Oil Controversy in Southeast Asia, A Transnational Perspective, ISEAS, Singapore, 2012.

Pye, O., Radjawali, I., and Julia: Land Grabs and the River, Can. J. Dev. Stud., Special Issue on Climate change policies, resource grabbing and conflict: perspectives from Southeast Asia, submitted, 2017.

Radjawali, I. and Pye, O.: Counter-mapping Land Grabs with Community Drones in Indonesia, Paper delivered at the international academic conference on Land grabbing, conflict and agrarian-environmental transformations: perspectives from East and Southeast Asia, 5–6 June 2015, Chiang Mai University, Thailand, available at: http://www.iss.nl/fileadmin/ASSETS/iss/Research_and_projects/Research_networks/LDPI/CMCP_80-Radjawali_and_Pye.pdf (last access: 9 January 2017), 2015.

Radjawali, I., Pye, O., and Flitner, M.: Recognition through Reconnaissance? Using Drones for Counter-mapping in Indonesia, J. Peasant Stud., Special Issue on Southeast Asian Perspectives on Agrarian-Environmental Transformations, in print, 2017.

Robbins, P.: Political Ecology, Blackwell Publishing, Oxford, UK, 2004.

Sandvik, K. B. and Jumbert, M. G.: The Good Drone, Routledge, London, UK, 2016.

Sandvik, K. B. and Lohne, K.: The Rise of the Humanitarian Drone: Giving Content to an Emerging Concept, Millennium-J. Int. St., 43, 145–164, doi:10.1177/0305829814529470, 2014.

Smith, L., Bratini, L., Chambers, D., Jensen, R. V., and Romero, L.: Between idealism and reality: Meeting the challenges of participatory action research, Action Research, 8, 407–425, 2010.

Swandiri Institute: Towards Spatial Transparency: Rapid Socio-Spatial Assessment of Extractive Industries in West Kalimantan, Indonesia, The Extractive Industries Transparency Initiative Final Report, 2014.

Van Klinken, G.: Blood, timber, and the state in West Kalimantan, Indonesia, Asia Pac. Viewp., 49, 35–47, 2008.

Wainwright, J. and Bryan, J.: Cartography, territory, property: postcolonial reflections on indigenous counter-mapping in Nicaragua and Belize, Cult. Geogr., 16, 153–178, 2009.

Watts, A. C., Perry, J. H., Smith, S. E., Burgess, M. A., Wilkinson, B. E., Szantoi, Z., Ifju, P. G., and Percival, H. F.: Small Unmanned Aircraft Systems for Low-Altitude Aerial Surveys, J. Wildlife Manage., 74, 1614–1619, 2010.

Waylen, K. A., Fischer, A., McGowan, P. J. K., and Milner-Gulland, E. J.: Deconstructing Community for Conservation: Why Simple Assumptions are Not Sufficient, Hum. Ecol., 41, 575–585, doi:10.1007/s10745-013-9594-8, 2013.