PUBLIC-PRIVATE ALLIANCE *for* RESPONSIBLE MINERALS TRADE

PPA Data for Impact Symposium

Discussion on Using Remote Sensing to Map Artisanal Mining in Sub-Saharan Africa with Tamma Carleton and Jihae Hong

Tamma Carleton, MOSAIKS, delivered the presentation on remote sensing, and project partner Jihae Hong, Project on Resources as Governance, joined the breakout discussion to support responses to attendee questions.

Attendee 1: I'm wondering about your point on using machine learning and remote sensing in combination with other sources of information to look at the volumes of minerals, or the throughput of minerals through formal channels or the due diligence sphere. As you put it with geographic context, not necessarily being a template for others, the approach needing some adjustments to fit context. I assume that distinguishing between licensed or unlicensed or any degrees of formalization spectrum might be a challenge.

Tamma: We have some data on commercial mining activities. Right now, that model is leveraging the visual signal of a commercial mine and an artisanal mine to try to detect artisanal mines, which is why it's helpful to have both, and how formal commercial mines are much easier to see. They're largescale, big clearings.

And there is some prior work showing that as well. To your point about where in the spectrum of licensure and in the legal domain, I think it's generally just going to be easier to see where those are. But there's also better registries of them, so the need for remote sensing is potentially lower. We see the potential for remote sensing to really have an impact is on the unlicensed ASM side. On the volume side, that's interesting. I don't think our current data we're trading with tells us anything about volume or throughput.

I could imagine, to the extent that the scale of the mine is correlated with the volume that's being extracted, that could be potentially possible to see imagery. But again, we just require the type of ground truth data to train the model. Right now, we're training on," is there anything happening here or not" which is a hard problem, but sort of the most basic problem. Then training on how much mining is happening in this place.

I think you could do that, but we haven't opened that door yet. On the generalizability, the ground truth data we have particularly outside of Sierra Leone or a few places throughout the country where the government has administrative records that they think ASM is happening, even if you don't want to extrapolate from country A to country B, the value of remote sensing to fill in predictions of ASM across all grid cells within that country. All our experiments suggest that those are really high performing predictions. And even that in and of itself is a really important, valuable contribution. Even if you're not then saying, "well, let me take this to Country B," filling in our data collection efforts within country A itself is potentially really viable.

Jihae: Back to your first question about the mineral volume, it is correct that we don't have volume information. But I think what this mapping will enable to see is the intensity of activity for an area. It could be a province or a smaller administrative unit. And I imagine that people have skepticism around these numbers about their mineral export country, maybe production, numbers by province is possible. ITSCI has more detail, information about production, information about the mines that apprenticed in its program.

So if we can access other data, maybe that's a comparison we can do with the complete mapping information. There's an ability to compare to what may be really, truly happening on the ground and the incomplete data that we know we have on hand.

Attendee 2: I'm curious about the ground truth information that you are using, because we know that information is not always perfect because smuggling takes place. There are all sorts of incentives for movement of minerals once they're taken. It's interesting to think about how this model could even help with understanding where something's not right.

Tamma: I totally agree. And a metric that I haven't reported, but I think we should going forward, is that we take the government reported data and then we manually check every single point and then identify was there actually a mine here as we can see in the high resolution imagery or not? Or is it just moved over? Or is it really never here? We have some initial summary statistics on accuracy based on what you can see in the image of the underlying administrative data, which we correct before training the model. So even that first preprocessing correction step could be interesting in terms of getting a general sense of reliability of the underlying industry of data.

Attendee 1: Also part of the quandary, especially given the fact that if we're thinking of artisanal sites on the one hand and commercial or industrial sites on the other, even among artisanal sites, there is kind of a spectrum of formalization that doesn't necessarily translate all the time into physical characteristics.

That's really what's so challenging. In the sites in the DRC where there's probably been some rollout or uptake of due diligence, these are sites that, while there's a degree of formality when it comes to the way that minerals are traded, I don't think anyone who's a formalization expert by looking at the site would consider these to be formalized sites in the sense that they have some kind of mine planning systematized, overburden removal, or any kind of safety techniques. By and large, that's not the case at these sites.

Whereas if you look at a few sites, it's still certainly the exception rather than the norm. But in in the cobalt and copper supply chains, where I guess the initial scrutiny or the impetus for the scrutiny of that sector was a little bit more tied to occupational health and safety, that's where you are seeing some physical signs of formalization where there's a little bit more of that mine planning. And maybe there would be signatures that would show up in those cases based on your approach. If there's any physical or spatial signature to sites where there's not a great deal of earthworks or engineering formalization, but there is some level of formalization when it comes to the way the trade of minerals is conducted, that would be interesting.

Tamma: Yeah. And you open a lot of really interesting questions which relate to inherent limitations of satellite imagery to learn things. One thing we could do, at least as a starting point, is if we have any data on even a few regions or cases, or we know something about the degree of formalization, it's possible to see errors in the model or differential across regions of higher or lower formalization.

That can be really important if we're systematically under- or over- predicting, and maybe under-predicting in places that are less formalized. That's pretty important to know if we're thinking about who might use this intimate approach. I don't know whether we can get enough data to assess that. But I think even if we couldn't use it in actual model training, it can be a dimension along which we take care to assess where the errors are largest and communicate that information carefully.

Attendee 3: From my own personal experience with CARPA, I've noticed quite a number of reported, additional mines existing on the boundaries of industrial mines. So you have industrial mine X and then, just outside those fences, you have a series of artisanal miners hoping to get rich by being right on the

border of it. Does the model in any way cater for these boundary conditions? Or do these artisanal mines disappear in the shadow of the industrial mine? Have you looked at that?

Tamma: I don't know off the top of my head how that's doing either in training or in in measures of prediction and testing. Most the lion's share of our data are just ASM. If they were on the edge of a commercial mine, it might be that where it's easier for us to find them and we're more likely to accurately detect them. But we haven't systematically assessed it.

Jihae: The way that we prepared artisanal and commercial data, we did not follow the same protocols. I think the commercial data came from kind of pre-prepared polygons that trace commercial lines. if I am remembering correctly, with artisanal mines, we started with a set of cells. And we didn't look at every grid cell for a province, for example. We started with a random subset. So in terms of the training data, I doubt that those artisanal mines that might be surrounding commercial mines were included in the in the training data. But in terms of prediction, I'm assuming that cell that has a commercial mine, it's just kind of saying that there's a mine here.

Tamma: Yeah. But I think it's a great point. We can easily check among our 14,000 points how many of them are doing that, butting right up against the polygons of the commercial mining, and get a sense of whether those are easier or harder to detect. I didn't know that that's common, so it's worth looking into.

Attendee 2: One thing I'm curious about, and I know that there are probably so many implications or potential linkages to other work, but thinking about the ethics of sharing certain data, the different ways that people might use this information certainly wouldn't want it to be used to like, help prospecting, I guess, especially in sensitive regions.

But it could certainly be helpful for thinking about where mine sites might be permitted by governments, and especially if there were ways to link the mapping to it, to some of the ecological mapping. I know I have some colleagues who are working with Google Earth engine to map specifically sensitive environmental protection regions and to help to identify these areas should be off limits versus where there might be better places to support development.

That's obviously quite sophisticated and I'm not sure how much the DRC government, for one, would engage in that. Anyway, have you thought about who might you want to share the data with, and for what purposes? And what are the kind of concerns that you have about how data might be used.

Tamma: I think where you're headed is like, overlaying maps of intensity of activity with other outcomes that we think are potentially affected by mining, like environmental damage or even sensitive populations. In terms of the potential health effects of unlicensed mines, we haven't gotten that far, but I think that's a really interesting idea. In terms of who to share with and how, I come from the machine learning remote sensing side here, and I come with a lot of trepidation about what would happen if we just put a map up on the Internet. We're definitely not doing that. Jihae works a lot more with stakeholders and thinking through this decision. But my general take has been to be cautious and defer to my colleagues who work in this space in terms of how we're going to navigate it going forward.

Jihae: Yes, that's a real concern. And, to be honest, I don't think we really have a strong stand on that right now. But part of the reason that we wanted to look at this like technology for potential mapping is in our work with regulators in West Africa, they've often mentioned a need for this type of more targeted monitoring ability to target their field staff to discover new mines. And they're quite excited about the potential for remote sensing to guide their work in that way.

But as Tamma said, we have similar concerns because it's true that some of these ASM activities might be leading to like environmental harm or some negative consequences for the surrounding community. But at the same time, it's livelihood for many, many people who need it. We are trying to figure out what's the trade-off in terms of risking, potentially, individual livelihood, miners' livelihood, and also whether this is the tool that can be used for regulators to better effectively monitor this sector.

Back to your initial question about how it might complement a conservation effort. I think that was actually one of the first user groups that we thought about because in Liberia, a lot of the ASM that happens in Liberia is happening in protected areas. I think people have some sense it being rampant, but they don't know the true extent, like how extensive is it in comparison to areas where mining is permitted? We still think that this type of way to quantify the level or intensity of ASM activity is useful for organizations that are working on conservation of sensitive area environments.

Attendee 3: Maybe just a comment. In addition to the ethics of data sharing, I know artisanal miners are particularly targeted when it comes to conflicts because they typically don't have the resources or the government backing to defend themselves. So when it comes to data sharing, especially now, is conflict picking up again in that part of the world? I can imagine that it's not necessarily the best situation to share with the armies and the rebel groups that are now present in that part of the world.

And also, finally, have you already written up your results in a paper or something? Is this something to read?

Tamma: We're working on it! We're really working on that extrapolation piece. Prior work has been done and we have not yet assessed it, and we really want to assess it carefully before moving forward.

Remote sensing utilizes a new computational infrastructure that dramatically lowers the computational cost and, thus, allows users to expand the prediction and mapping of ASM activities across various mineral types and terrains in sub-Saharan Africa. These predictions can inform regulators and watchdog groups that monitor the extent of ASM activity and track its impacts.

Tamma Carleton is an Assistant Professor at the Bren School of Environmental Science and Management at the University of California, Santa Barbara. Her research combines economics with datasets and methodologies from remote sensing, data science, and climate science to quantify relationships between environmental change and economic development. Her current work focuses on climate change, water scarcity, and the use of remote sensing for global-scale environmental and socioeconomic monitoring.

Jihae Hong is the Managing Director of the Project on Resources and Governance. She previously worked for Innovations for Poverty Action where she established the Myanmar Country Program and oversaw a portfolio of impact evaluations on land rights, nutritional cash transfer, vocational education, and information and communications technology in Myanmar and Mongolia. Jihae has a bachelor's degree in mathematics a master's degree in Quantitative Methods in Social Science.
