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Transparency or Map-Washing? Digital Geospatial Visualisation Tools in the Palm Oil Industry

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ABSTRACT

We introduce the notion of map-washing and ask whether digital geospatial visualisation (DGV) tools distort information or provide greater supply chain transparency. Map-washing explains a process of disclosing spatial information that has little or no value to the intended users, but rather creates, conforms to or distorts a particular narrative. In the context of advancements in satellite technology, cloud-based geographic information systems and sophisticated web-based digital programming, we observe the rise of sophisticated web-based tools that offer geospatial visualisations of business activities. Firms across a broad range of agro-commodities are investing in DGV tools as part of efforts to achieve greater levels of transparency in their operations. The function of these tools, their intended audiences and the broader environmental and social outcomes remain unclear. Our research is based on a desk-based analysis of DGV tools employed across the palm oil industry, and interviews with informed stakeholders in the palm oil and related industries. From 97 companies assessed in the study, we identified 16 companies with active DGV tools. We found that companies employ a spectrum of geospatial visualisation tools that differ in the technologies used, data inputs, level of interactivity, type of collaborations and the outcomes and degree of stakeholder participation. We argue that the spatialisation of palm oil supply chains achieves a sophistication in corporate communication that is more difficult to achieve with traditional CSR reporting. Yet we also contend that the transformative power of these tools is open to debate, arguing that map-washing may deflect attention away from negative externalities. We propose guidelines and regulation as a means to enhance the positive contributions of DGV tools to sustainability and transparency.

1 | Introduction

Advances in the integration of satellite technology, cloud-based geographic information systems (GIS) and sophisticated web-based digital programming have prompted the rise of tools that offer digital geospatial visualisations (DGV) of agro-commodities (Padfield, Dales, et al. 2023; Global Forest Watch 2024; Nusantara 2024; Trase n.d.). DGV tools are used to annotate maps of a landscape or a supply chain, and users can interact with these maps via the internet without the need for specialist software. Versions of these tools integrate geospatial information—typically gathered from satellite or existing geospatial available software, such as Google Maps—with data corresponding to a company's supply chain, including resource type, supplier information, and sustainability credentials (see[1] SD Guthrie 2025; SIPEF 2021).

DGV tools have emerged against a backdrop of criticism aimed at industry-led transparency policies and practices. Esty and Karpilow (2019) contend that existing sustainability disclosure

practices are ill-equipped to address the informational needs of mainstream investors. Traditional disclosure methods, such as corporate and social responsibility (CSR) reporting, online databases and scorecards, footprint calculators and publication of supplier lists (Cho et al. 2015), cannot meet the requirements of investors who seek corporate sustainability metrics that are aligned with business fundamentals to help mitigate risks of unsustainable practices. Mol (2015, 155) argues that a new form of 'placeless transparency' has emerged as transparency systems become part of transboundary markets, networks and flows rather than being grounded in specific places. Likewise, following a comprehensive analysis of transparency tools in agro-commodity supply chains, Gardner et al. (2019) argue that these tools rarely connect systemically with the places in which a commodity is produced.

The global palm oil industry is one of the earliest adopters of technologies on supply chain transparency, including the use of DGV tools (SD Guthrie 2019; SIPEF 2021). Palm oil is the most consumed vegetable oil in the world (Tullis 2019) and is associated with significant environmental and social issues such as deforestation, habitat loss and worker exploitation (Hansen et al. 2015). In the last two decades, different types of organisations and groups have raised concerns about these sustainability challenges to drive change in industry practice. Non-governmental organisations (NGOs) such as Greenpeace have focused their attention on the sourcing strategies of larger brands who utilise palm oil in their products (Chen et al. 2019). Pressure also comes from consumer groups who raise public awareness of the sustainability concerns connected to palm oil and advocate for more responsibly sourced products (Reardon et al. 2019). The formation of sustainability certification standards such as the Roundtable on Sustainable Palm Oil (RSPO), Malaysian Sustainable Palm Oil, Indonesian Sustainable Palm Oil, and industry level policies such as no deforestation, no peat and no exploitation (NDPE) have prompted palm oil firms to disclose increasing amounts of sustainability information about activities in their supply chains (Padfield et al. 2016).

Public governance is also playing a role in palm oil sustainability following the introduction of the European Union Deforestation Regulation (EUDR). EUDR concerns deforestation associated with the conversion of land for soy, beef, palm oil, wood, cocoa, coffee, rubber and their derived products. From 2024, producers of palm oil intending to export to the European Union (EU) must demonstrate that their product is deforestation-free and that due diligence and risk mitigation procedures to prevent deforestation are in place (European Commission 2023). High levels of scrutiny and increasing demand for improved sustainability practices from various stakeholder groups explains why the palm oil industry is at the forefront of supply chain transparency advancement. Yet questions remain about the extent to which new technologies such as DGV tools improve sustainability and organisational transparency, and the role they play in the corporate communication of business activities.

Our paper investigates the emergence of DGV tools in the palm oil industry and proceeds as follows. Drawing on the supply chain and critical perspectives of spatial transparency literatures, we introduce the notion of map-washing and ask whether DGV tools distort information or offer greater transparency. Map-washing explains a process of disclosing spatial information that has little or no value to the intended users, but rather creates, conforms to or distorts a particular narrative. To contextualise discussions on map-washing in the next section, we review the academic literature on supply chain transparency and critical perspectives of spatial mapping tools. Next, we explain our method of data collection and analysis of palm oil industry DGV tools, including interviews with stakeholders from across the palm oil supply chain. Key findings and discussion are presented in the next sections to offer insights on the purpose, scope and scale of DGV tools in the palm oil industry while providing an empirical typology of these tools. Our analysis reveals how the tools function, their intended audiences, and offers insights on the sustainability impacts and outcomes of these tools. Finally, we reflect on the broader contribution of geospatial visualisation tools to the sustainability of the palm oil industry. We argue that while there are a number of positive outcomes associated with DGV tools, disclosing very particular or selective geo-spatial information about a company's activities (e.g., map-washing) may deflect attention away from negative externalities. We end our discussion section by proposing guidelines and regulation to enhance the positive contributions of DGV tools to sustainability and transparency.

2 | Literature Review

2.1 | Supply Chain Transparency

A company gathers information about its supply chains to evaluate risk, increase efficiency and enhance supply chain visibility. Companies can increase organisational transparency by disclosing supply chain information to the public, including consumers and investors (Sodhi and Tang 2019). Companies increase supply chain transparency to increase sales and market share (Schnackernberg and Tomlinson 2016), while demonstrating legitimacy, accountability and trustworthiness to boost their reputation (Albu and Flyverbom 2019). Kraft et al. (2019) found that increased supply chain transparency generates trust and increases consumer sales. Companies increase supply chain transparency through CSR communication for a variety of purposes; for example, stakeholder management; image enhancement; legitimacy and accountability; attitude and behavioural change; sense-making; and identity and meaning creation (Crane and Glozer 2016).

As a CSR communication tool, transparency is a complex communicative, organisational and social process that is full of tensions and negotiations (Albu and Flyverbom 2019). Transparency depends on both 'visibility and accessibility of information especially concerning business practices' (Bhaduri and Ha-Brookshire 2011, 135). Stohl et al. (2016, 134) warn that increasing visibility through 'a sea of unstructured and boundless data' can overwhelm third-parties and reduce transparency, giving rise to a 'transparency paradox'. The following paragraphs unpack these risks, challenges and paradoxes.

Reflecting on transparency initiatives in the agro-commodities sector, Gardner et al. (2019, 164) argue that 'the impact of increased transparency depends fundamentally on what

information is being made transparent, how, to whom and for what purpose'. They introduce the idea of *transformative transparency*, a process of disclosure of information by organisations which can support improved decision-making with a view to protect the environment and vulnerable stakeholders. They argue that transformative transparency 'can help in reshaping human relations with nature and society towards a more sustainable and equitable future, and away from a dominant trajectory of over-consumption, environmental degradation and capital accumulation' (Gardner et al. 2019, 164). The authors in the study identified six dimensions of information made available to others:

1. traceability information that links supply chain actors to production sites;
2. transaction information about patterns of investment and ownership;
3. impact information that concerns sustainability standards;
4. policy and commitment information that concerns the regulatory framework for actors in the supply chain;
5. activity information about reported actions that supply chain actors undertook; and
6. effectiveness information that reports on the effectiveness of interventions implemented to reduce negative environmental and social impacts of the supply chain.

Effectiveness information (Dimension 6) is critical for determining how much progress in terms of sustainability is made in a location or by an actor. Thus, it is important to understand how these six dimensions are required to support the recurrent cyclical process of assessment and intervention, which is needed to improve sustainability conditions on the ground (Gardner et al. 2019, 165).

Since informational stimulus can affect judgement (Haddock and Maio 2004), disclosing information that is *valuable* to stakeholders can drive them to perceive the disclosers as accountable. So, when does transparency becomes valuable? In the literature, there is no generally agreed model to measure disclosure quality, and focusing only on the quantity of information is misleading because it does not indicate better disclosure of companies' activities (Fernandez-Feijoo et al. 2014; Plumlee et al. 2015), and more information can increase opacity (Stohl et al. 2016). To achieve accountability, disclosed information must be accessible, reliable and facilitate interpretation; it shows openness, as opposed to hiding facts; and it is diverse as opposed to being too narrow (Wong et al. 2021). The main tension here is 'corporations will never voluntarily disclose information that will hold them accountable' (Hess 2007, 457).

Egels-Zandén et al. (2015) distinguish between internal supply chain transparency, the degree to which a company is inwardly transparent, and external supply chain transparency, the degree to which a company is outwardly transparent to stakeholders. Increased supply chain visibility can facilitate internal operational (efficiency) gains, as more information about the supply chains operations help companies to manage resources more effectively (Wong et al. 2021). More often, transparency enhances visibility of risks (including sustainability risks) in multi-tier supply chains. Since some risks reflect non-compliance, companies will not disclose all the risks they know to external stakeholders, meaning they will have more internal transparency.

Disclosure of supply chain information rarely covers all of Gardner et al.'s (2019) six dimensions of transparency since many companies are concerned about external transparency and have reasons not to fully disclose certain types of information. Firms may choose to present a partial picture of their operations, cherry-picking information or evidence as part of their disclosure process (Milne and Gray 2013). This practice is referred to as selective disclosure: 'a symbolic strategy whereby firms seek to gain or maintain legitimacy by disproportionately revealing beneficial or relatively benign performance indicators to obscure their less impressive overall performance' (Marquis et al. 2016, 483).

Roszkowska-Menkes et al. (2024) identify three forms of selective corporate disclosure: vague disclosure, avoidance and hypocrisy. In a comprehensive study of corporate sustainability reporting, they found 'sustainability-related controversies still tend to be frequently concealed from stakeholders' (Roszkowska-Menkes et al. 2024, 16). Selective disclosure is akin to *greenwashing*, where an individual or business promotes their activities as sustainable while continuing to operate in a socially and/or environmentally damaging way (Kopnina et al. 2023, 14). Likewise, in a recent analysis of blockchain technology—defined as a record of transactions shared across a network of users and individually verified by each participant (Mashatan and Roberts 2017)—Bernards et al. (2024) argue it fails to address persistent sustainability problems in supply chains and instead acts as a *veil of transparency* over marginalised people and environmental abuses.

2.2 | Critical Perspectives of Spatial Transparency Tools

Corporate transparency initiatives, particularly in commodity sectors operating across multiple scales and geographies, are integrating spatial dimensions within their corporate disclosure efforts (Gardner et al. 2019). Beyond the suite of more conventional tools and methods, companies are investing in tools that represent geospatial aspects of business activity. These tools address the challenge of displaying and communicating big geospatial data that are intended to enhance the sustainability of complex supply chains. In 2019, Nestlé launched a palm oil transparency dashboard to share more detailed information with stakeholders about how the company uses satellite monitoring to meet their commitment to a deforestation-free palm oil supply chain (Nestlé 2020). Nestlé partnered with the European aviation company Airbus and an NGO called Earthworm Foundation to implement Starling, a satellite-based monitoring system, to identify deforestation risks across their whole palm oil supply chain. These spatial technologies have the potential to improve conservation and sustainable land management (European Space Agency 2023), moving commodity firms closer to Gardner et al.'s (2019) notion of transformative transparency.

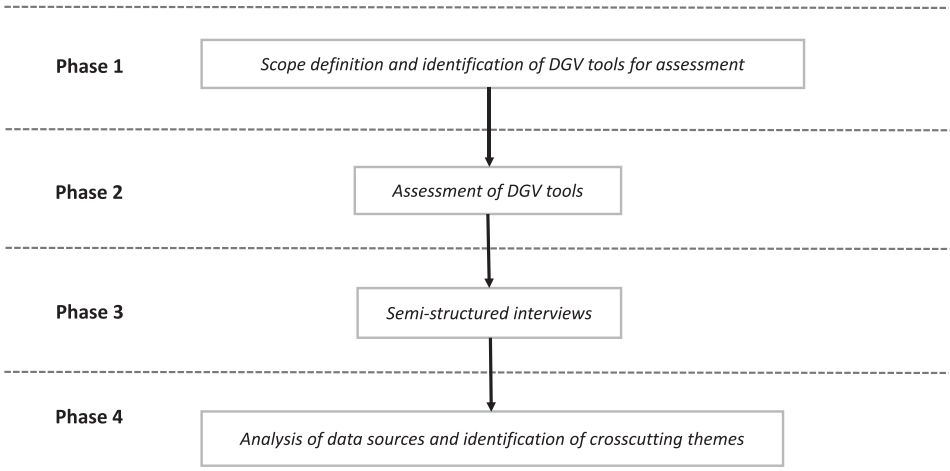

FIGURE 1 | Methods flow of data collection activities and analysis.

There is a well-established literature in human geography arguing for a careful examination of map making strategies (Harley 1989; Kitchin et al. 2011; Wood 1992). Kitchin, Perkins and Dodge (2011, 9) argue that maps are steeped with the 'values and judgements of the individuals who construct them and ... are undeniably a reflection of the culture in which those individuals live'. Moreover, maps are often expressions of uneven power relations since they can be products of privileged and formalised norms which produce particular kinds of knowledge about the world (Kitchin et al. 2011). In the context of corporate spatial transparency tools, map architects have the power to decide who is represented and what level of information is disclosed, sometimes leading to 'people being pushed off the map' (Kitchin et al. 2011, 9).

Maps represent an explicit expression of power, values and interests in the palm oil sector. Oil palm producers can withhold concession maps and the geo-coordinates of their production areas for legal and commercial reasons, even if this results in non-compliance with local laws and sustainability standards (Mongabay 2016). In response to corporate land grabbing, De Vos (2018) reported the actions of villagers in West Kalimantan, Indonesia who mapped their own community boundaries to prevent oil palm firms mapping the territory themselves to facilitate a land ownership claim.

New mapping technologies introduced in the palm oil industry should also be viewed within the limitations of current regulatory structures of sustainability governance. As Pye (2019, 221) argues, 'they [palm oil firms], and only they, are awarded the active part: "to clean up their act"'. Despite multi-stakeholder initiatives such as the RSPO, palm oil producers are the main arbiters of any new technologies and initiatives to improve transparency and sustainability. While there is an absence of regulation of new technology such as DGV tools—as is often the case in the context of new digital products (Zwitter and Hazenberg 2020)—companies can decide what and who is captured on their maps, which reinforce social inequalities and ambiguities around land use change.

While there are case studies of participatory digital tools in the fields of crisis mapping and urban mapping and their role in the empowerment of users (Asmolov 2020; de Vos 2018), less is known about the production of geospatial visualisation tools by corporations for supply chain transparency. For example, there are questions around which stakeholders' voices are being heard, the process of sense-making, and any actions taken as a consequence of the map creation. It is also necessary to consider the ownership, access and control over data that feed into geospatial visualisation tools. Spatial digital data tends to be generated on demand by networks of global technology companies and subsidiary organisations that produce high impact geospatial visualisation tools (European Space Agency 2023). The structure of power relations within this process may determine the scope and scale of transparency, as well as the visual representations of geospatial data based on value judgements, strategic, commercial and legal considerations.

3 | Methods

This study examines the purpose, scope and scale of DGV tools in the palm oil industry to understand how DGV tools function (transparency or map-washing), and their intended audiences. We also examine the sustainability impacts and outcome of these tools on key human and non-human stakeholders. Finally, we reflected on the innovation potential of DGV tools to support improved responsibility within the broader agricultural commodities sector. To achieve our objectives, we conducted the research in four phases as demonstrated in the process flow of data collection activities and analysis below (see Figure 1).

3.1 | Phase 1: Scope Definition and Identification of DGV Tools for Assessment

In this phase, we defined DGV tools as those which palm oil producers have developed themselves and are publicly available on corporate websites. DGV tools should include a map that identifies locations of palm oil activities and related information, including but not limited to one or more of the following: plantations, mills, refineries, soil types and land ownership boundaries. Our definition is intentionally broad in view of the variety of different types of DGV tools used by palm oil producers. Following this activity, we gathered information about palm oil companies from the Sustainability Policy Transparency Toolkit (SPOTT) palm oil 2022 assessment (https://www.spott.org/palm-oil/). From this database we collected information on

TABLE 1 | Summary of interview participants.

Interview code	Organisation type	Role/responsibility	Date of interview	No. of interviewees
I#1	Global food manufacturer	Director of Feed Safety; Senior Raw Material Manager; Safe & Ethical Purchasing Compliance Manager	11 May 2021	3
I#2	Palm oil producer	Director of Sustainability	26 April 2021	1
I#3	Independent sustainability consultant	Consultant	1st April 2021	1
I#4	Environmental NGO	Director, Technical Services	21 April 2021	1
I#5	Environmental NGO	Senior Advisor	27 April 2021	1
I#6	Palm oil producer	Head of Sustainability	26 April 2021	1
I#7	Environmental NGO	Head of Finance	30 April 2021	1
I#8	Environmental NGO	Head of Policy	20 April 2021	1
I#9	Independent commodity certification agency	Research and Advisory Manager	8th July 2021	1
I#10	Palm oil producer	Regional Director|Environment & Conservation Department	16 April 2021	1
I#11	Retailer	Group Responsible Sourcing Manager (Forests)	15 April 2021	1
I#12	Consumer goods company	Sustainable Sourcing Director	27 April 2021	1
I#13	Consumer goods company	Global Head of Sustainable Sourcing	6 May 2021	1
I#14	Conservation NGO	Technical Advisor; Business Project Analyst	15 June 2021	2
I#15	Palm oil producer	Operations Manager	1 June 2021	1
I#16	Conservation consultancy	Technical advisor	19 March 2024	1

the size of individual firm's landbank, and market value. The RSPO website (https://rspo.org/) was accessed to determine whether the firms were RSPO members, and if so, the year in which they achieved member status. From the 97 companies listed in the SPOTT 2022 assessment, we examined each firms' public website to identify those with an available DGV tool monitoring palm oil activities.

3.2 | Phase 2: Assessment of DGV Tools

We designed an analytical framework to examine the types and quality of information provided in the DGV tools. This includes information on the scope and scale, time-based data, data granularity as well as the level of complexity/sophistication and interactivity with users. With this information, we were in a position to derive a typology of DGV tools.

3.3 | Phase 3: Semi-Structured Interviews

We conducted interviews with representatives from organisations from across the palm oil supply chain, including producers, retailers, NGOs, consultants, consumer good companies, food manufacturers and a certification agency. Table 1 provides a summary of the interviewees, organisation types and roles and responsibilities. To select participants, we applied a purposive sampling strategy that allowed us to focus on specific areas of interest and gather in-depth data on specific topics (Clark et al. 2021) concerning the DGV tools. Furthermore, it allowed us to select respondents that were most likely to provide useful information and important views on the topics to meet the objectives of the research, thus improving the rigour of the study and trustworthiness of the data and results (Clark et al. 2021). Interview questions can be found in the Supporting Information.

Participants were invited to take part in the interviews via email. Consent forms and participant information sheets were sent to those that agreed to take part. The interviews were conducted online between April and July 2021, and focused on understanding interviewees' perspectives of the purpose and outcomes of DGV tools, as well as their broader role in agro-commodity transformation. While an interview guide was used, we adopted a flexible approach, which provided latitude to ask further questions in response to what were seen as

significant replies or different interpretations, and to ensure valid answers (Brinkmann 2013).

3.4 | Phase 4: Analysis of Data Sources and Identification of Crosscutting Themes

In this final phase, we analysed across the different data sources to identify key themes, arguments and trends (Padfield, Varkkey, et al. 2023). Interview transcripts from Phase 3 were read for content in a reflective and interpretative manner by three members of the research team (Miller and Crabtree 1999). We employed abductive analysis to derive primary and secondary codes (see the Supporting Information for a coding table) and these were assigned to the interview transcripts. We then compared and contrasted these codes with the findings from analysis of palm oil industry DGV tools derived in Phase 2. To ensure validity of the analytical process, the researchers undertook periodic validation checks of codes, themes and theme clusters. An abductive approach allowed us to make sense of the new insights, tensions and surprises within the context of prior knowledge and theory (van Hulst and Visser 2024).

4 | Key Findings

4.1 | General Trends

Table 2 presents the selected characteristics of palm oil companies who have invested in DGV tools. The information presented includes company landbank (thousands of hectares [Kha]), market capital, year joined RSPO and a description of the DGV tool indicating the level of transparency and interactivity. In Table 3, we compare aggregate data on palm oil firms with and without DGV tools, including data on the total landbank, average landbank per firm and the location of industry activities.

Overall, firms with large land banks are investing in DGV tools. These firms tend to have membership to the RSPO; 13 out of 16 are members. These firms have well established operations in Southeast Asia and within this sample, a smaller number are active in oil palm production in other parts of the world. Firms investing in DGV tools represent approximately 36% of the total global land bank of palm oil but only comprise of 16 companies out a total of 97 companies. Firms without DGV tools represent 64% of total global land bank of palm oil but comprise of 81 out of a total of 97 companies. Firms without DGV tools operate globally with a large concentration of activities in frontier geographies of oil palm production—West and Central Africa and Latin America.

4.2 | Typology of DGV Tools

From our analysis of publicly available information provided by palm oil firms via their corporate websites, we developed a typology of DGV tools as shown below. DGV tools have been categorised based on their level of interactivity with users, transparency of activities, data granularity and sophistication of information communication (see Table 3).

4.2.1 | Level 1: Basic Transparency

Level 1 DGV tools are characterised by minimal information and low interactivity, which overall offers a basic level of supply chain transparency. This level of DGV relies on simple maps without satellite or GIS-style imagery, often only indicating the region or general location of facilities and estates. Maps are typically static which reduces the ability to zoom into a specific area or catchment where production activities are located. The names of mills and plantations and other facilities are provided but with limited additional information, for example, geolocation coordinates, RSPO certification status and relevant traceability data.

4.2.2 | Level 2: Moderate Transparency

Level 2 DGVs tools utilise web-based software to display their supply chain activities (e.g., Google Maps and OpenStreetMap), which allows a degree of user interactivity. Additional information is often provided as part of the maps, such as links to transparency reports and RSPO certification status. There are no additional data layers incorporated such as land use types, forest protection status, fire incidences or land ownership.

4.2.3 | Level 3: High Transparency

The main features of the Level 3 DGV tools are the high degrees of interactivity, a wide variety of granular data pertaining to production activities and the ability to overlay various land cover information to situate activities within the context of landscape change and governance. For instance, in addition to geographical coordinates and shape files, Level 3 tools provide information such as the facility and estate name, owner details, RSPO certification status and traceability details of the certified palm oil, as well as landscape data such as deforestation, protected forest areas, peatlands and fire incidents. In the case of the DGV tool developed by SD Guthrie, RSPO grievance data has been provided, which includes details of the grievance, a summary of the specific actions taken by the firm to address the grievance and reference to media reports about the case. These tools often require more complex programming and integration of different data sources, including satellite imagery, and collaboration with technology firms and universities. The high level of sophistication of Level 3 tools is comparable with DGVs managed by NGOs and universities, such as the Forest Watch mapping tool (https://www.globalforestwatch.org/map/), the Nusantara Atlas deforestation tracking tool (https://nusantara-atlas.org/) and the University of Chicago Data Science Institute PalmWatch Tool (https://palmwatch.inclusivedevelopment.net/).

4.3 | Purpose of DGVs for Palm Oil Producing Firms

Analysis of the scope and scale of publicly available DGVs, and interviews with palm oil producing companies, reveal two main purposes of DGVs to the palm oil companies themselves. First, the tools facilitate map-washing in the selective, partial communication of their company supply chain transparency activities to externally facing stakeholders. As one palm oil producer commented: 'We set it up for our customers to show that we

TABLE 2 | Characteristics of palm oil companies with DGV tools.

Company	Location	Landbank (KHa)	Market capital	Year joined RSPO	DGV mapping tool URL	Level of transparency: Level 1—Basic; Level 2—Moderate; Level 3—Good	Description of DGV tool
Asian Agri Group	Indonesia (North Sumatra, Riau, Jambi)	161.9	Private co.	2006	https://www.asianagri.com/en/sustainability/traceability/	2	Simple Google base map; location of mills and downstream facilities; clicking on pins reveals a drop-down menu offering links to summary reports; zoom in/out function
Astra Agro Lestari Tbk PT	Indonesia (Aceh, Riau, Jambi, Central Kalimantan, East Kalimantan, South Kalimantan, West Sulawesi, Central Sulawesi)	286.7	$1036.0M	n/a	https://www.astra-agro.co.id/pemetaan-rantai-pasok-2/?fasilitas=3&regional=2&nama=4&submit=submit	2	Simple Google base map; location of mills provided; links redirect the user to traceability reports; location of mills provides latitude, longitude coordinates; zoom in/out function
BLD Plantation Bhd (Bintulu Lumber Development (BLD) Plantation)	Sarawak,Malaysia (Sibu and Bintulu)	51.3	$195.4M	n/a	http://dashboard.bldpb.com.my/transparency.html	2	Simple Google base map; location of mills indicated with pins; geolocation coordinates not provided; zoom in/out function provided

(Continues)

TABLE 2 | (Continued)

Company	Location	Landbank (KHa)	Market capital	Year joined RSPO	DGV mapping tool URL	Level of transparency: Level 1—Basic; Level 2—Moderate; Level 3—Good	Description of DGV tool
Boustead Plantations Bhd	Malaysia (Johor, Kedah, Kelantan, Pahang, Penang, Perak, Sabah, Sarawak, Terengganu)	98.2	$345.9M	2004	https://www.bousteadplantations.com.my/maps-location/	1	Static map; locations of estates, mills and laboratories shown; geolocation coordinates not provided; no zoom in/out function
Cargill Inc	Indonesia (South Sumatra, West Kalimantan)	189	Private co.	2004	https://www.cargill.com/page/cargill-mill-locations	2	Simple Leaflet/OpenStreetMap; location of mills provided; a separate link that directs the user to a list of mills, including geolocation coordinates, RSPO status and supply chain classification; zoom in/out function
Golden Agri Resources Ltd	Indonesia (Bangka Belitung, Central Kalimantan, East Kalimantan, Jambi, Lampung, North Sumatra, Papua, Riau, South Kalimantan, South Sumatra, West Kalimantan).	582.6	$2634.0M	2005	https://www.goldenagri.com.sg/sustainability/responsible-sourcing/supply-chain-map/	2	Simple Google base map; location of mills and downstream facilities; clicking on pins reveals a drop-down menu offering links to summary reports; Location, RSPO status, % of verified traceability

(Continues)

TABLE 2 | (Continued)

Company	Location	Landbank (KHa)	Market capital	Year joined RSPO	DGV mapping tool URL	Level of transparency: Level 1—Basic; Level 2—Moderate; Level 3—Good	Description of DGV tool
Kuala Lumpur Kepong Bhd	Malaysia (Johor, Kedah, Kelantan, Negeri Sembilan, Pahang, Perak, Sabah, Selangor), Indonesia (Central Kalimantan, East Kalimantan, Riau, North Sumatra, Bangka and Belitung islands), Liberia	356.1	$4948.4M	2004	https://www.klk.com.my/sustainability/market-place/traceability/	2	Simple Google base map; location of mills, KCPs, refineries; geolocation coordinates provided, and links to traceability reports
M.P. Evans Group plc	Indonesia (Aceh, Bangka Belitung, East Kalimantan, North Sumatra, South Sumatra)	74	$547.4M	2006	https://www.mpevans.co.uk/plantations/map-and-locations	1	Static map; limited interactivity; clicking on pins opens a new window with information about location (no geolocation coordinates) and planted area; links provided to RSPO webpage
Musim Mas Holdings Pte Ltd	Indonesia (Central Kalimantan, North Sumatra, Riau, South Sumatra, West Kalimantan, West Sumatra).	199.4	Private co.	2004	https://www.musimmas.com/sustainability/traceability/	2	Simple Google base map; limited interactivity; locations of refining and kernel crushing facilities; clicking on pins reveals a new window with links to traceability reports for some of the facilities; zoom in/out function

(Continues)

TABLE 2 | (Continued)

Company	Location	Landbank (KHa)	Market capital	Year joined RSPO	DGV mapping tool URL	Level of transparency: Level 1—Basic; Level 2—Moderate; Level 3—Good	Description of DGV tool
Peak Palm Oil plc	Guinea	5.3	Private co.	n/a	http://peakpalmoil.com/index.php/about-peak-palm-oil/about-guinea/guinea-locations	1	Static map; no interactivity; location of areas (a single dot); no zoom in/out function, no geolocation coordinates provided
R.E.A. Holdings plc	Indonesia (East Kalimantan)	80.1	$58.5M	2007	https://www.rea.co.uk/websites/reaholdingsplc/English/3650/maps.html	1	Static map; no interactivity; location of plantations and mills provided; geolocation coordinates shown

(Continues)

TABLE 2 | (Continued)

Company	Location	Landbank (KHa)	Market capital	Year joined RSPO	DGV mapping tool URL	Level of transparency: Level 1—Basic; Level 2—Moderate; Level 3—Good	Description of DGV tool
SD Guthrie	Indonesia (Central Kalimantan, Central Sulawesi, Jambi, Riau, South Kalimantan, South Sulawesi, West Kalimantan), Malaysia (Johor, Kedah, Malacca, Negeri Sembilan, Pahang, Perak, Sabah, Sarawak, Selangor), Papua New Guinea, Solomon Islands.	626.6	$6709.2M	2004	https://smart.sdguthrie.com/gisportal/apps/webappviewer/index.html?id=36e336808bb24fe6981847e4ddfecd94	3	Interactive map with extensive information points and layers; global mill list, refineries and plantations; smallholders; grievance register and status; different layers of information provided, e.g., conservation landscapes, protected areas, concession areas, areas of deforestation, areas of past fires; zoom in/out function; explanatory text on methodologies underpinning the tool

(Continues)

TABLE 2 | (Continued)

Company	Location	Landbank (KHa)	Market capital	Year joined RSPO	DGV mapping tool URL	Level of transparency: Level 1—Basic; Level 2—Moderate; Level 3—Good	Description of DGV tool
SIPEF	Indonesia (South Sumatra, Bengkulu, North Sumatra), Papua New Guinea (Bialla, West New Britain Province)	134	$635.8M	2005	https://www.geosipef.com/	3	Interactive map with extensive information points and layers; zoom in/out function; locations of mills and factories, e.g., supply estates, smallholders, palm oil crushing; availability of different layers of information e.g., conservation landscapes, protected areas, concession areas, areas of deforestation and fires; RSPO membership details of estates and mills
Triputra Agro Persada Group PT	Indonesia (Central Kalimantan, East Kalimantan, and Jambi)	155.6	$854.9M	2007	https://www.tap-agri.com/map	1	Static map; locations of plantations and mills, no zoom in/out function, Geolocation coordinates provided on a separate hyperlink

(Continues)

TABLE 2 | (Continued)

Company	Location	Landbank (KHa)	Market capital	Year joined RSPO	DGV mapping tool URL	Level of transparency: Level 1—Basic; Level 2—Moderate; Level 3—Good	Description of DGV tool
TSH Resources Bhd	Indonesia (West Sumatra, Central Kalimantan, East Kalimantan, North Kalimantan), Malaysia (Sabah).	98.3	$312.2M	2014	https://www.tsh.com.my/plantations/	1	Static Google base map; limited interactivity; no zoom in/out function; location of estates and mills provided, no geolocation coordinates
Wilmar International Ltd	Ghana, Indonesia (Central Kalimantan, Jambi, North Sumatra, Riau, South Sumatra, West Kalimantan, West Sumatra), Malaysia, Nigeria, Uganda, Côte d'Ivoire	354.2	$18,512.7M	2005	https://www.wilmar-international.com/sustainability/supply-chain-transformation/traceability/supply-chain-map	2	Simple interactive map; limited interactivity, no zoom in/out function; location of refineries; by clicking on pins a new window opens up with links to traceability reports of mills, NDPE progress data.

TABLE 3 | Comparison of palm oil firms with and without DGV tools in terms of total landbank (Kha), average landbank per firm and location of activities.

	Nos. of firms	Total landbank (Kha)	Average landbank per firm with DGVT (Kha)	Location of industry activities
Firms with DGV tools	16	3453	216	Majority of activities located in Southeast Asia—Malaysia, Indonesia, Papua New Guinea and Solomon Islands. A small number of activities in West Africa—Ghana, Nigeria, Uganda, and Côte d'Ivoire.
Firms without DGV tools	81	6119	120	Global representation Southeast Asia—Indonesia, Malaysia, Papua New Guinea West and Central Africa—Liberia, Sierra Leone, Nigeria, DR Congo Latin America—Columbia, Brazil, Guatemala
Total	97	9572		

have a fully transparent supply chain. But also to get points on SPOTT' (Interviewee I#10). The tools are regarded as another instrument in which external stakeholders can make sense of the complexities of supply chain transparency and sustainability and accordingly, complement the myriad of existing CSR communication activities (Interviews I#3 and I#14). NGOs, governments, financial investors and research institutes, for example, can use these tools to access vast amounts of data without needing sizeable resources or specialist GIS teams. Information gleaned from the DGV tools can then be scrutinised and incorporated into externally-managed reporting initiatives or investigations such as Global Reporting Initiative (GRI) reports, RSPO reporting, academic research, NGO campaigns and data submissions for external evaluative exercises such as SPOTT and WWF (Interviews I#1, I#2, I#3, I#9, I#10, I#11, and I#15). DGV tools can also be incorporated into evidence of deforestation-free supply chains to demonstrate compliance for the EUDR (SD Guthrie 2025).

For palm oil companies with comprehensive data sets, DGV tools bring together existing information into a digital spatial platform without the need for new data gathering. One palm oil producer stated that there was 'an ambition to develop a communications tool to map things out. But in parallel, we were using lots of data sets, we used geospatial data ... on reflection, we thought that the tool would help people to visualise things better, so we published layers of it' (Interviewee I#6). Less resourced companies were not in the same position and the cost and resources required was a barrier (Interviewee I#2). One palm oil producer based in South America identified the satellite imagery costs, including the regularity of the satellite information required and the human resources needed to verify and manage the information against supply chain data as a notable barrier to the development of a more sophisticated DGV tool (Interviewee I#2).

The second main purpose of DGV development has a more strategic, internal benefit to palm oil producers. Interviewees revealed improved opportunities for risk assessment within their supply chains (Interviews I#3, I#6, and I#10). 'Tools can be used to see if a supplier poses a risk, depending on the reasoning and what the parameters are, then that supplier might be cut out of the supply chain. For example, anti-bribery and corruption, we cannot work with anybody who would jeopardise the business on that respect' (Interviewee I#6). Another palm oil producer argued that risk management was not their first intention but after 'seeing how useful it is to map things out, it helped identify risk areas in the supply chain and in specific geographies' (Interviewee I#10). In summary, a representative from the NGO community working in the palm oil industry argued that DGV tools 'can allow for improved ability to manage business-to-business relationships, to provide investors with information about where their money is being spent, which helps to support risk management and improves how to manage opportunities in the industry' (Interviewee I#7).

4.4 | Audience and Uses

To understand the uses of DGV tools it is pertinent to establish their audience(s). Analysis of the interview data in this study identified four primary audiences of DGV tools. The first are downstream actors, such as manufacturers, processors and retailers who buy and source directly or indirectly (e.g., via derivatives of crude oil palm) from producers and traders. The second are governmental stakeholders, such as commodities, agricultural and environmental agencies and ministries. In this category we also include public policy stakeholders such as EU competent authorities involved in the implementation of the EUDR (European Commission 2023). The third are financial investors and speculators. The fourth are not-for-profit organisations such as the RSPO

and Greenpeace, and independent industry evaluation bodies such as the WWF and Zoological Society London (ZSL) who administer the SPOTT annual evaluation. In addition, secondary audiences include researchers (e.g., independent consultants and academics), news media and the public more broadly.

The uses of DGV tools by the identified stakeholders broadly align with the main purposes of these tools by the palm oil companies (see Section 4.3 above), although there is variation in the degree to which users engage with specific information accessible in the DGVs. In general, the downstream actors we interviewed use DGVs to gain insight on various data points in the supply chain (Interviews I#12, I#13 and I#14). For example, to verify the country of origin of sourced palm oil, detailed locations of growers or mills, whether palm oil is sourced inside or outside a concession, proximity to sensitive ecosystems (e.g., rainforest and peatlands), and RSPO compliance (Interviews I#1, I#3 I#7, I#9, I#10 and I#12). Further, an NGO interviewed in the study justified the use of these tools by arguing that customers 'want to know where their products are coming from and if they are causing deforestation...people want to know where their food is coming from ... We need the tools that link those things, and that is traceability and transparency' (Interviewee I#4).

Despite the wide audience for DGV tools, the extent to which the data is used by stakeholders is mixed. For example, the Zoological Society London scrutinise closely DGV tool data for their annual SPOTT assessment (e.g., geo-referenced maps for all third-party supplying plantations [https://www.spott.org/spott-methodologies/]) (Interviewee I#14). Other stakeholders use the tools in more of a light-touch manner. A UK-based retailer argued that their supply chain was too large to use DGV tools in a meaningful way to scrutinise the transparency and sustainability of individual companies and products. Instead, the retailer relied on third party sources (e.g., Sedex [https://www.sedex.com/about/]), which assess the sustainability of thousands of supplier supply chains (Interviewee I#11).

The appeal and utility of spatial representations of complex supply chains compared with more conventional written reports is important to a number of users. Interviewees mentioned the benefits of DGV tools over conventional written reports. 'Visualisation is better than a table or a chart. It is always better received. The source of the material, from high, medium and low risk areas. The source can be shown using geospatial tools' (Interviewee I#3). However, some firms are also reluctant to visualise: 'Some producers are avoiding providing geospatial information in the form of a shape file. None of them are using shape file maps in their tools. [*Name of company withheld*], for example, only provide information in PDF format and only for their operations in Malaysia... and their map is non-interactive' (Interviewee I#3).

4.5 | Environmental and Social Impacts

Interviewees from across a range of stakeholder groups participating in this study indicated that DGV tools form one part of the process towards improved palm oil sustainability and broader organisational transformation in the industry (Interviews I#1, I#2, I#3, I#4, I#5, I#9, and I#14). A representative from an independent commodity certification agency observed that while it is too soon to assess their impact, DGV tools are 'important in terms of driving organisations to more sustainable practices, and sustainable food systems' (Interviewee I#9). The primary impact identified by stakeholders was greater clarity on unsustainable practices in producer supply chains, particularly concerning environmental impacts, for example deforestation and the burning of peatlands. Making data available for public consumption in a spatial form has enabled companies to seek answers to questions about their supply chain, which in turn creates opportunities for changes to current practices. By contrast, investment in DGVs can also be regarded as map-washing in the form of appeasement or distraction. There are real challenges facing companies, for example, from forensic scientists who are working on the ground (or in the air), determining the causes of fires and illegal land conversion. Companies can use DGVs to lay the blame for fires on third parties to avoid liability, or to distract the public or media from the real issues on the ground.

Social information and impacts, such as community conflicts, worker livelihoods and labour rights do not feature strongly on any of the DGV tools. Some of the palm oil producers we interviewed referred to the complexities and potential tensions of making social information data available for public use, particularly as it concerns data protection, exposing identities of workers, and aggravation of existing community-company or local community-community conflicts (Interviews I#2, I#6, and I#15). Despite these limitations, the representative of an independent commodity certification agency observed that a select number of producers have recognised the importance of data diversification represented on DGVs beyond environmental data. Initial discussions have been held by some companies on the prospect to merge existing socio-economic conditions data into DGV tools (Interview I#9).

5 | Discussion

What does an analysis of DGV tools in the palm oil industry tell us about their utility and the broader contribution of geospatial visualisation tools to the sustainability of the agro-commodities sector? We make three distinct arguments in this section. First, we argue that DGV tools play a significant role in the gradual evolution of supply chain transparency, and these spatial representations serve the interests of firms of a certain size in specific regional geographies. Secondly, we use the idea of map-washing to explain how DGV tools may reshape corporate sustainability narratives. Our argument calls into question the overall efficacy of DGV tools in the context of transparency initiatives in the agro-commodities sector. Finally, we call for greater recognition of the role played by DGV tools in the communication and transparency strategies of agro-commodities firms, which in turn would benefit from agreed standards and regulation administered by governmental and non-governmental stakeholders.

5.1 | Geography Matters: The Spatialisation of Palm Oil Supply Chain Communication

DGV tools are an innovative way to communicate to new and existing audiences the complexity of palm oil supply chains. Compared with conventional communication tools, such as

lists of growers and mills and quantities and types of certified palm oil as presented on corporate websites and in annual sustainability reports (see United Plantations 2022), DGV tool's defining characteristic is the spatialisation of supply chain data. Countering Mol's (2015) critique of early CSR transparency initiatives as *placeless transparency*, the integration of a spatial lens brings a greater sense of place into the way palm oil producers present their supply chains, and to a certain extent practices taking place in these supply chains. Indeed, the more sophisticated versions of the tools—for example, Level 3—can provide relatively precise geo-referenced data on a variety of spatially relevant supply chain informatics (instruments and mechanisms of production), such as mills, plantations, refineries and concession areas. Mapping supply chain data over layers of biophysical characteristics—for example, intact forest and soil types—generates far more nuance and spatialised representations of palm oil production than can be described in textual form. Thus, opening up and publishing data on business activities in a spatialised way forms an important part of the trust building between producers and the range of external stakeholders (Kraft et al. 2019).

The integration of different forms of supply chain data on interactive maps achieves a sophistication in communication that is far harder to achieve through conventional corporate communication. Drawing on Crane and Glozer's (2016) definition of transparency—see Section 2—our study suggests the DGV tools have at least four primary outcomes: (i) manage risk and individual stakeholders in the supply chain; (ii) enhance the image of palm oil producers; (iii) increase firm legitimacy; and (iv) make sense of supply chain activities to external stakeholders. In short, demonstrating supply chain transparency through DGV tools create multiple benefits for the firms that choose to undertake this (arguably worthwhile) investment.

But who are the palm oil producers trying to build trust with, and what do differences in innovation uptake amongst producers say about the utility of DGV tools? We demonstrate from our analysis of the different types of audiences of the tools—see Section 4—that there are a variety of stakeholders who may engage with the tools, including downstream buyers, investors and NGOs such as SPOTT appraisal managers. There is no single standout stakeholder that agribusiness firms are targeting, which suggests a broad and open motivation for development of the tools. There is an uneven uptake of DGV tools across the industry. As demonstrated in Tables 2 and 3, it is a small number of the larger firms (e.g., with larger land banks) that are choosing to invest. Furthermore, these firms are primarily located in Southeast Asia. This reveals a potential source of tension in the industry as some of the largest firms in Southeast Asia (e.g., SD Guthrie, Wilmar and Cargill) have participated in sustainability governance initiatives (e.g., members of RSPO working groups and NDPE policies) while also being some of the most criticised firms by NGO campaigns (see Jong 2019). These firms are often targeting export to the EU and thus these tools form part of the evidencing of deforestation-free supply chains to meet EUDR compliance. Considering the high levels of public visibility and scrutiny facing these firms, there is a clear motivation for the largest firms operating in Southeast Asia to invest in tools that demonstrate, or give the impression of, transparency innovation in their supply chains. The investment in DGV tools is driven by commercial imperatives, helping with corporate brand image and legitimacy, while the impact on sustainable land use or transparency is difficult to measure.

A contrasting picture emerges when analysing the medium and smaller sized firms. The evidence suggests that there is less of a strategic priority to invest in DGVs. These firms operate across all parts of the global production landscape, including the frontier geographies of Central and West Africa and Latin America. In these regions, operations are characterised by less formalised governance frameworks and smaller production volume of RSPO certified palm oil (Dauvergne 2018), while also subject to a whole range of sustainability challenges (Ogahara et al. 2022). Minimising public visibility of company data and operations is likely to be more of a strategic priority for these firms (Hess 2007).

Overall, our research highlights a divide between larger firms operating primarily in the production centres of Southeast Asia compared with smaller firms operating across less established areas for production. The contrasting levels of engagement with sustainability initiatives by large and smaller firms is consistent with past studies examining palm oil industry sustainability practices (Padfield et al. 2016). DGV tools appear to be playing a role for larger firms—particularly in terms of their own legitimacy, image building and evidence of public policy compliance (e.g., EUDR)—compared with smaller firms, many of whom work in places with less scrutiny, are not exporting to regions with sustainability policy requirements, and thus seek to minimise accountability and transparency of their operations.

5.2 | Map-Washing and the Control of Corporate Sustainability Narratives?

While DGV tools contribute in unique ways towards corporate sustainability and transparency initiatives, questions remain about the extent of their transformative impact. In this section we contend that DGV tools can facilitate a form of map-washing that contributes to the careful control of a firm's sustainability narrative.

So, what is map-washing and what does it mean in the context of this study? Similar to greenwashing, sportswashing and brandwashing that aim to mislead or distract from actual business practices (Lantos 2012; Skey 2022; Torelli et al. 2020), DGV tools tell a particular story about a company's activities. The clean and sanitised representation of the agro-commodity supply chains featuring pins, icons, colours, coordinates, hyperlinks and so forth, obscure the messy nature of production landscapes. Even the most advanced interactive geospatial maps can selectively strip out the everyday realities of palm oil production on a community and landscape; everything from the benefits it may bring, for example contributions to livelihoods and infrastructure, to the harmful impacts, for example ecological destruction, pollution, species extinction and community conflict. In the same way that human geographers argue that maps reflect the interests, values and judgements of the individuals or organisations who create them (Harley 1989; Kitchin et al. 2011; Wood 1992), DGV tools can reduce commodity production to a series of graphics representing isolated parts of the production

process layered over a digital map. Information on the transactions between companies and different actors in the supply chain may not be present, obscuring a reality that is characterised by complicated public–private ownership, as well as offshore ownership that prioritises sales and growth (Varkkey 2015). The maps produced by DGV tools help audiences reimagine palm oil supply chains, and the outcome for the user—whether intended or unintended—is a disconnect from the lived experiences of humans and non-humans located in these risk environments. In sum, DGVs can be used to (re)create a particular narrative targeted at specific stakeholders that obscures a firm's actual relationship with ecological and societal sustainability; thus, rather than achieving transformative transparency, DGV tools could be associated with a *high-tech status quo* transparency.

Major oil palm companies in Southeast Asia are facing consumer pressure and are targeted by environmental NGOs. They can attempt to regain the initiative by producing their own sophisticated DGV tools as a counterweight to the maps and tools used by conservationist groups to hold companies accountable for harmful land use change. Even with advanced DGV tools, are RSPO-registered agri-businesses really enhancing the visibility of company data and operations? Or are they obscuring more than they are revealing? Climate defenders, conservation organisations and activists are already exposing company practices, for example, by sharing concession maps and spatial planning assessments, and supporting corruption investigations (Charters et al. 2019). In this context, DGV tools can be used by companies to deflect attention away from negative press and lawsuits, and to recapture the narrative.

The EUDR requirement for companies to evidence transparency and deforestation-free supply chains has the potential to prevent or limit the degree of map-washing by companies. For example, SD Guthrie (2024) state that their Crosscheck DGV tool is used to help the company adhere to the requirements of the EUDR. External verification of information contained in the DGV, therefore, implies a high degree of accuracy and reliability. Conversely, since there is no regulation of the information presented in DGV tools, companies can provide parallel sets of information to the EUDR while also presenting a different set of information within a DGV tool. Compliance with the EUDR and other similar types of public policies may help to improve the accuracy of information in the tools; however, it does not prevent companies map-washing in cases where information presented in the tools is kept separate to the information bundles submitted for scrutiny by external bodies.

Three characteristics underpin the map-washing observed in this study. Firstly, the DGV maps present a largely linear and technocratic conceptualisation of palm oil production (e.g., supply chains), transparency and sustainability. The focus of information and data is located around the producers, mills and in some cases, information on the owners of the mills, such as level of sustainability certification. There is little transparency over impacts in adjacent environments. Impacts and changes over time are rarely included in these maps, and as expected, many factors are concealed. Sensitive issues pertaining to community and indigenous land rights and impacts on food security are almost entirely absent from the maps. Little information of the impacts over time are represented in the tools, for example, how was the area used before palm oil? Is the concession subject to community conflict or is it an area of high ecological or conservation value? What longer-term impacts are predicted to take place in production landscapes? Accordingly, the tool curators hired by the companies are in control of the selectivity of information presented in the DGVs. Drawing on Roszkowska-Menkes et al.'s (2024) forms of selective disclosure, the tools can present a deliberately vague picture of a particular sustainability issue, or simply avoid any reference to the experiences of communities and workers affected by agri-business production and land use change.

Secondly, there are no industry guidelines or standards for the regulation of information presented in the tools, so companies can select as much or as little information as they wish to disclose. In the case of palm oil companies, they may choose to annotate their maps with RSPO information, land use and terrain types, fire incidence and other data; alternatively, they may chose not to include any additional layers of data. The information excluded from the tools is as revealing as the information presented. Well-resourced firms with a Level 3 DGV tool (see Table 3) may choose to add different layers while other firms may keep their DGVs simplistic or not invest in them at all. Indeed, it is possible that the liabilities associated with data disclosure (e.g., court cases, reputational damage and accusations of non-compliance with sustainability certification) outweigh any internal benefits of increased supply chain transparency.

Thirdly, the lack of collaboration between palm oil producers on DGV tool development underlies the necessity to tell distinctive, individual stories about their supply chains rather than more holistic stories, for example, catchment level assessments. The lack of collaboration between companies suggests the firms are out to protect themselves. Adams et al. (2016) note that the most transformative types of company innovations are those that seek to build collaborative capacity with external stakeholders to change broader behaviour, culture and practices. The heterogeneous and ad hoc manner of DGV tools in the agro-commodity sector implies that the tools are regarded as distinguishers between companies rather than as opportunities to work towards common sustainability and transparency goals.

5.3 | Recognition and Regulation of DGV Tools

The emergence of geospatial technology to monitor environmental and business indicators suggests that DGV tools will continue to play a role in agro-commodity analysis and communication into the future. This creates new opportunities as well as challenges, such as the selective presentation of information by companies that can reinforce—rather than challenge—existing sustainable business narratives (O'Dochartaigh 2019). To address these challenges and support efforts towards transformative transparency (Gardner et al. 2019), we call for greater recognition amongst DGV curators of the utility and efficacy of these tools in communication and transparency strategies of agro-commodities firms. We argue this could be achieved by reflecting on how DGV tools could disclose information that better represents the *messy realities* of palm oil production, thus improving transparency and the chances for more sustainable production. As a priority, this process should include the

integration of community and worker experiences, which remain absent in current DGV tools and have been shown to have limited presence in corporate sustainability disclosure studies (Roszkowska-Menkes et al. 2024). Collaboration between palm oil firms and affected local stakeholders during the curation of the DGV tools will create opportunities to represent their experiences in the maps. Recognition of the power held by the map makers—and the power they have to present an alternative story—might reduce the tendency for communities to be misrepresented or 'pushed off the map' (Kitchin et al. 2011, 9).

The targeted regulation of DGV tools will help to enhance their contribution to transparency and disclosure practices in the agro-commodity sector. While there are limits to the positive effects of regulation (Grimmelikhuijsen et al. 2024), a formalised and agreed approach to DGV tools can offer guidance on the type, range and scale of information acceptable for dissemination. The guidelines for DGV tools should be established and monitored by various stakeholders, which should include governmental and non-governmental actors. Tools failing to meet the agreed guidelines around information accuracy and disclosure could be highlighted and map owners informed of the regulatory requirements. The regulations and guidelines would only apply to DGV tools developed by palm oil producers as opposed to non-corporate DGVs tool (e.g., Global Forest Watch and Nusantara) since the objective would be to standardise the industry-led communication of supply chain sustainability.

6 | Conclusions

The emergence of DGV tools in the palm oil industry presents opportunities for transformative transparency (Gardner et al. 2019), an ambitious concept that has the potential to enhance the sustainability and transparency of a notoriously complex commodity that is ubiquitous in global production and supply chains. The main benefit of advanced DGV tools with interactive features is that external stakeholders gain better access to granular data concerning activities in a company's supply chain. The palm oil producers themselves can benefit from improved risk management, as well enhanced legitimacy and trust building between producers, downstream stakeholders, and their critics. Improvement is still needed across the industry as a whole since there is a tendency for selective disclosure of information (Roszkowska-Menkes et al. 2024) and map-washing. We found that investment in DGV tools is more common amongst the RSPO-compliant firms with large landbanks operating in Southeast Asia. The emergence of deforestation-free regulations such as the EUDR provides greater justification for DGV investment by these firms to demonstrate their compliance. Medium- and smaller-sized companies, and those operating predominantly in Africa and Latin America, are not investing in these new technologies to the same degree. We argue that the differences in DGV tool adoption is in part explained by visibility; innovation is taking place amongst those who are most comfortable to be scrutinised in the public domain and have the capacity to put that ambition into practice.

We argue that the spatialisation of palm oil supply chains achieves a sophistication in corporate communication that is more difficult to achieve with traditional CSR reporting. The ability of DGV tools to zoom-in and zoom-out from specific places, extract sizeable amounts of previously inaccessible data, and place business activities in a wider geographical context is potentially game changing for the agro-commodities sector. The DGV tools in the palm oil industry, particularly those with more detailed transparency and opportunities for interactivity, are beginning to challenge the idea of placeless transparency (Mol 2015, 155). A number of the tools examined in this study are shown to offer a far more situated and geographically grounded concept of transparency.

At the same time, we have introduced the term map-washing to describe a process of selective disclosure of spatial information that has little or no value to the intended users, but rather creates, conforms to or distorts a particular narrative. We have argued that, rather than achieving transformative transparency, DGV tools in their current form produce a high-tech status quo transparency. Considering the heavy scrutiny and the pressure applied to different parts of the palm oil industry to disclose information, stakeholders should be wary of attempts by companies to map-wash as DGV tools continue to evolve. Maintaining a critical enquiry as to the true motivations, intended audiences and data underpinning the tools is essential going forward.

The fledgling nature of DGV tools in the agro-commodity sector means there are plenty of unresolved questions to examine for future research. We have identified a number of priority themes as follows. First, it is important to understand how such tools influence wider policy and practice within the palm oil industry. Asmolov (2020) argues that the symbolic value of maps does not necessarily lead to action; following the same logic, it is critical to determine the wider influence exerted by DGV innovation. As referred to in Section 5.3, it is also important to understand how best to regulate DGV tools, especially as they become more mainstream and referenced by external stakeholders to verify supply chain data.

Second, it is important to explore how the lived experience of communities and workers is affected by palm oil production and how this can be integrated into DGV tools; currently, there is limited representation or participation by such groups in the tools. An important ethical consideration is to ensure that communities or individuals who do participate can do so without the fear of reprisal—whether their employment, livelihood or safety.

Our research findings can help firms in the agro-commodity industry better understand the importance of DGV tools for enhancing business sustainability strategies. Bager and Lambin (2020) found that transparency initiatives in the global coffee sector, such as investment in traceability technology, are only being pursued by a small group of companies. They also found that these companies adopted significantly more sustainability practices compared to non-transparent companies. Thus, the adoption of DGV tools has the potential to enhance transparency while positively influencing more comprehensive business sustainability strategies. For example, firms across industries contribute to biodiversity loss through multiple drivers (e.g., land use change and over exploitation of resources) and they need to mitigate those drivers and report on the progress with strategies for biodiversity protection (Panwar et al. 2023). Use of more advanced DGV tools can inform the design and

implementation of strategies for biodiversity protection (e.g., conservation and restoration), help monitor progress, enhance transparency and make communication about biodiversity efforts more authentic. Furthermore, DGV tools can complement other technological solutions for sustainable supply chains such as blockchain to enable more integrated sustainability strategies (Khan et al. 2022).

Finally, we recommend further research that explores the relationship between innovation, corporate communication and organisational culture. Analysis of the values and attitudes of palm oil company executives and managers towards sustainability should improve understanding of the motivations behind the selective disclosure of information and limited collaboration across DGV tools. For example, does investment in sustainability related tools reflect changes within organisational culture, including a shift in a company's values and vision? To what extent is innovation a reflection of external communication needs or a genuine interest in sustainability and transparency? And ultimately what or who drives investment in transparency innovation within an organisation? All of the above can be extended to other agro-commodities, which create opportunities for comparative studies.

Author Contributions

Rory Padfield: Conceptualisation, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, supervision, writing – original draft and writing – review and editing. **Suzana Matoh**: Conceptualisation, data curation, formal analysis, investigation, methodology, project administration, writing – original draft and writing – review and editing. **Adam Tyson**: Conceptualisation, data curation, formal analysis, funding acquisition, writing – original draft and writing – review and editing. **Chee Wong**: Conceptualisation, data curation, formal analysis, funding acquisition, writing – original draft and writing – review and editing. **Gemma Bridge**: Conceptualisation, data curation, formal analysis, investigation, methodology, project administration, writing – original draft and writing – review and editing. **Alexandra Dales**: Formal analysis, writing – original draft and writing – review and editing.

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Conflicts of Interest

The authors declare no conflicts of interest.

Endnotes

[1] SD Guthrie, formerly known as Sime Darby Plantation Berhad.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.