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Innovation for zero-deforestation sustainable supply chain management services: a performance measurement and management approach.

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ABSTRACT

Purpose: Food sector supply chains have significant negative environmental impacts, including the expansion of global food commodity production which is driving tropical deforestation - a major climate and biodiversity problem. Innovative supply chain monitoring services promise to address such impacts. Legislation also designates 'forest-risk commodities', demanding supply chain due diligence of their provenance. But such data alone does not produce change. We investigate how theory in performance measurement and management (PMM) can combine with sustainable supply chain management (SSCM) via case study research that addresses paradoxes of simplicity and complexity.

Method: Given existing relevant theory but the nascent nature of the topic, theory elaboration via abductive case study research is conducted. Data collection involves interviews and participative design workshops with supply chain actors across two supply chains (coffee and soy), exploring the potential opportunities and challenges of new deforestation monitoring services for food supply chains.

Findings: Two archetypal food supply chains structures (short food supply chains with high transparency and direct links between farmer and consumer, and complex food supply chains with highly disaggregated and opaque links) provide a dichotomy akin to the known/unknown, structured/unstructured contexts in Decision Theory (DT), enabling novel theoretical elaboration of the Performance Alignment Matrix model in PMM, resulting in implications for practice and a future research agenda.

Originality / value: Our novel conceptual synthesis of PMM, SSCM and DT highlights the importance of context specificity in developing PMM tools for SSCM, and the challenge of achieving general solutions needed to ensure that PMM, paradoxically, is both flexible to client needs and capable of replicable application to deliver economies of scale. To advance

understanding of these paradoxes, in order to develop network-level PMM systems to address deforestation impacts of food supply chains and respond to legislation, a future research agenda is presented.

INTRODUCTION

Grassini et al. (2013) show the rate of yield growth in agricultural commodities has not significantly increased since the 1990s. Hence, rising global food demand has been primarily met by land-use conversion, expanding the total global area of agricultural land. The environmental crisis of tropical deforestation is thus majority driven by rising levels of food demand for global markets.[1] Cassman & Grassini, (2020) show the promise of sustainable intensification (increasing yield within a set area) remains unfulfilled. Therefore, to achieve a more sustainable global food system, the link between increased production volumes and increased deforestation for land-use change to agriculture must be broken. Lambin et al. (2018) highlights the role of supply chain management initiatives in achieving this.

Following the United Nations' 2014 New York Declaration on Forests and Global Goals for 2030 Target 'SDG 15.2 '*end deforestation and restore degraded forests*'[2], some 450 members of the Consumer Goods Forum pledged in 2015 to achieve zero-deforestation supply chains (ZDFSC) by 2020, with individual company pledges and codes of conduct following. Sector initiatives, including commodity-specific sustainability certification schemes, were

[1] https://comtradeplus.un.org/
[2] https://www.globalgoals.org/goals/15-life-on-land/

established, and a range of monitoring services using satellites and other technologies, plus environmental league tables, were launched (see Appendix Table A).

With major food businesses having missed the goal for ZDFSC by 2020, regulators began introducing mandatory supply chain due diligence requirements for importers of goods designated as 'forest-risk commodities'. These include the UK 2021 Environment Act, the 2023 German Supply Chain Due Diligence Act, plus Japanese, South Korean and Canadian legislation, plus the 2023 European Commission proposed directive on due diligence for corporate sustainability. Within these, the 'forest risk commodities' include beef & leather, soy, oil palm, coffee, cocoa and rubber.[3]

Managers of food supply chains therefore face new legal requirements alongside sectoral and company-specific targets and policies. Yet, the past goals had not been sufficient to deliver change in operational supply chain practices. To understand how change in supply chain performance practice sufficient to meet the goals of ZDFSC, the researchers engaged with a multi-stakeholder group assembled to scope a new data and operational architecture for ZDFSC. This included food retailers and manufacturers, policy advisors, technical specialists in supply chain consultancy, land-use remote sensing and agricultural data analysts, plus academic researchers (the authors in business and management, and others in environmental science). This level of engaged research with practitioners aimed to develop an innovative demonstrator project for supply chain transparency services. For such regulations to be effective they must be enforceable, and so data services were called for providing impartial, accurate supply chain provenance information to be collected, assessed and acted on.

[2] Timber and derived products, such as paper & pulp, have been covered by existing voluntary certification schemes such as the Forest Stewardship Council and mandatory EU FLEGT (Forest Law Enforcement, Governance and Trade) regulations, impacting industries such as construction and publishing. As such, the food sector now needs to develop innovative, sustainable supply chain management processes (Leijten et al. 2022).

Within business and management studies, sustainable supply chain management (SSCM) (McIntyre et al. 1998; Carter and Rogers, 2008) concerns how supply chain managers can address social and environmental impacts, and performance measurement and management (PMM) is a goal-oriented management practice. Adapting supply chains to meet the goal of ZDFSC should see an integration between sustainable supply chain management (SSCM) practice and PMM, (Beske-Janssen et al, 2015). However, the PMM field has found that traditional PMM systems struggle with complexity (Franco-Santos & Otley, 2018), and deforestation and related commodity supply chains are identified as complex (Lyons-White & Knight, 2018).

Therefore, new approaches to PMM that address complexity are required in order to solve the SSCM problem of ZDFSC. The field of Decision Theory (DT) is thus used as a relevant perspective to address this problem as it considers how complex (unstructured) and simple (structured) contexts can be theorised and acted on (Fernandes and Simon, 1999; Snowden and Boone, 2007). The research thus concerns a synthesis of DT, PMM and SSCM via qualitative study. An additional model from innovation theory (Wheelwright and Clark, 1992) is also included as the attempt to develop such ZDFSC services that takes place alongside significant innovation in digital technology, including machine learning and big data, applied to supply chain management.

The research began from identifying deforestation as a major environmental problem (both species extinction and climate impact), and that global supply chains were driving this (Lambin et al. 2019). The lead researcher was part of a project to identify solutions in line with anticipated legislation for due diligence for ZDFSC, involving relevant parties, including policy-advisors working with Government designing this legislation, technical specialists in supply chain, agricultural and environmental data collection and analysis, and importers of

forest risk commodities potentially liable for disclosure under the regulations. The project timescale was two years from 2019 to 2021, with 18 months prior discussion during scoping.

The approach can be summarised according to the following research question, stated in two parts

1: How can supply chain managers conclusively establish that they are not sourcing commodities associated with deforestation?

This concerns the practical problem of integrating multiple sources of digital information (such as point of origin, route to market, environmental impact of production, social impact of production, etc. detailed in the data below), and do so in tandem with regulatory efforts.

Secondly, the more theoretical question,

2: How can PMM theory be adapted to help deliver ZDFSC given its complexity?

The project was to explore both the practical issues and potential theoretical perspectives to deliver impact. The methodology is thus exploratory case study following Yin (2008) on multiple cases and Eisenhardt (1989) on polar contrasts. Ketokivi & Choi (2015) is used as existing theories do not fully fit the topic (complexity, PMM, ZDFSC and SSCM). Hence, abductive theory elaboration informed by empirical case study is a valid and important scientific method, contrasted with inductive theory generation from data (without referring to existing theory), or large quantitative data seeking to test exiting theory. Sinkovics (2012) similarly highlights that qualitative research involves 'progressive focussing' between data and theory, with both being considered in parallel. Ketokivi & Choi (2015) note this parallel track is challenging to write due to less linearity than quantitative theory testing. As described by Pratt (2009), there is no boilerplate for qualitative research.

As such, we take a bold approach to the structure of this paper by providing the following format. In Section 2, we describe the project, including the parties involved and their role in forest risk commodity supply chains. Section 3 describes the method's validity and robustness. Section 4, findings, describes data collected. Section 5 then gives a theoretical reflection on the data collected, with a concise literature review of relevant material. Section 6, then gives a theoretical analysis of the data following the methodology papers above. Section 7 then gives conclusions, a future research agenda and implications for practice.

2: Project to research solutions for ZDFSC

In response to declared targets, services launched for ZDFSC included from NGOs (e.g. Global Forest Watch and Global Canopy), those focused on specific territories (e.g. Brazil, where the Amazon moratorium had been introduced), commodities (e.g. oil palm), or with a sector focus (e.g. those working with finance institutions) (see Appendix Table A). Initial meetings with food sector companies in the UK found these services generally not well-integrated into wider corporate systems for performance measurement and management (PMM) of supply chain practices. Partly, this demonstrated the lack of influence downstream, consumer-facing companies had over their upstream supply chains, especially for bulk commodities such as soy and oil palm. Some services, developed in close partnership with particular client organisations, were found to be completely at capacity meeting the needs of those clients, given that any given multi-national food manufacturer could have many thousands of different supply lines, coming from different regions and going into a vast range of products sourced from a great many different countries and local areas. This suggested room in the market for new entrants, plus existing services responded to voluntary targets not mandatory ones. Anticipated legislation requiring due diligence on exposure to deforestation, meant services needed corresponding to legal reporting standards.

The project explored two distinct supply chain case studies. First, a high street supermarket whose own-brand meat products were the largest part of their 'embodied deforestation footprint' via the Tier 2 soy animal feed purchased by their Tier 1 meat supplier. As noted by Ermgassen et al. (2020) for soy, and Lyons-White & Knight (2018) for palm oil, these feedstock commodities are characterised by supply chains of high complexity and opacity. Hence, a ZDFSC service must address this complexity, such as via better data gathering, or use of more general risk analysis.

However, before addressing a complex and opaque supply chain, a second contrasting case study with a known, simple, transparent supply chain was developed. Here, a prestige coffee manufacturer, with high quality standards and ethical procurement practices meant direct relationships with coffee farmers. The two cases represented two archetypes of supply chain structure, dubbed Complex Food Supply Chain (CFSC) and Simple Food Supply Chain (SFSC).

Working with the focal firm and supply chain partners to define user requirements, technical specialists on digital information including satellite imaging, isotopic provenance data, and supply chain production and export data, created a data stack to meet the policy requirements. Figure 1, below, shows the parties involved in the research. Appendix Table B shows the total data collected and roles of the participants.

INSERT FIGURE 1 HERE

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3. METHOD

Yin describes the case study method as suiting phenomenon that are novel or poorly understood (Yin, 2009, p2). Here, it is the attempt to answer companies' need for due diligence on deforestation risk in food supply chains..

Ketokivi and Choi (2014) show case study method as ideally suited for theory elaboration via its 'duality criteria', where the case research is situationally grounded but also seeks universal relevance. The method remains open to unanticipated empirical findings and the possibility that the theory or model may need altering to reconcile contextual idiosyncrasies and elaborate as mid-range theory (Eisenhardt, 1989, Pratt, 2009).

The two cases resulted from purposive sampling, which is suited to unique opportunities, namely the unique constellation of stakeholders including supply chain tiers, policy-makers, sustainability certification experts, environmental scientists, and technical supply chain data specialists, brought together by this initiative. As Barratt et al. (2011) state, "*Instead of statistical sampling from the defined population, case study researchers utilize a theoretical or biased sampling approach…[and] where cases have sharply contrasting characteristics.*" (p335)

A total of 17 organisations were included in the study, and more than one participant per organisation was interviewed as well as observed during project development workshops. A full list of interviewees by role is provided in Appendix Table B. Interviews were conducted using the elite interview technique, whereby informants see the researchers as equals due to prior experience in the field, leading to more frank and accurate discussion (Vaughan, 2013).

Additional insight was also gained from fieldwork in the forest-frontier regions of tropical countries where goods including coffee were grown for export. Secondary data collection included reviewing output from industry forums and trade associations, other professional reports, government policy consultations, public statements from companies, policymakers, and campaign organisations providing additional triangulation of interviewee data (Pauwels & Matthyssens, 2004). Triangulation was established by using multiple sources of data. This included interviewing subject experts (both academic and practitioner) not involved in the project, attending other policy workshops, meetings and webinars featuring similar supply chain actors and wider stakeholders, and reviewing reports by trade bodies, NGOs, policy think-tanks and others. This meets the criteria of Yin (2008) to incorporate multiple sources.

Audio recordings were transcribed, coded and reviewed by the research team to establish agreement (Saldaña, 2012). Validation of the evidence was made by checking with members of the design consortium through data-feedback sessions, and by other researchers not involved in the primary data collection. Content analysis of interviews, meeting discussions, reports and public presentations were captured via a data inventory and related coding sheets. Following Pauwels and Matthyssens (2004) and Sinkovics & Alfoldi (2012), codes were iteratively refined and elaborated upon, and continued until there was a saturation of themes and no new themes emerged; validity was established through triangulation, pattern matching logic and analytical generation (Barratt et al., 2011).

Interview quotes and accompanying initial and emergent codes are provided in Appendix Table C, quotes to which are referenced in the text, labelled Ref-X.X. The paper continues with a rich description of the innovation consortium and two related case studies, including key themes emerging from the data. The following section then provides a theoretical review before analysis in line with the empirical data.

4. EMPIRICAL FINDINGS

Overview of the zero-deforestation supply chain (ZDFSC) innovation project

As shown in Figure 1, the innovation consortium included 10 commercial organisations, each providing specific expertise and insight, coordinated by a publicly-funded agency.15 workshops, involving supermarkets, producers, NGOs and sustainable commodity certification bodies, were held, leading to a comprehensive set of user requirements. These then informed technical requirements, scoping of data sources, the building of a prototype data platform and accompanying service design.

User requirements included needing to comply with forthcoming deforestation due diligence regulations, help manage deforestation in the supply chain, verify suppliers claims of being deforestation-free to support buyer's ZDFSC targets, manage reputational risks of being associated with deforestation, gain awareness of and communicate wider environmental and social impacts in their supply chains, align with standard definitions of deforestation and specific dates and locations, near real-time deforestation alerts able to input into existing decision support systems and related actions such as for supplier selection, supplier deselection or supplier development.

Digital information ranged from farm locations to supply chain data on yields and logistics networks, plus deforestation monitoring over various spatial and temporal scales. Concerns included that data be impartial and independently verifiable, processes be replicable and scalable to other geographies and commodities, and alerts be accurate and not contain false positives.

Users' desired outcomes included checking past deforestation compliance and current estimated risk of suppliers for selection/deselection decisions. Another was supplier

development, whereby data could be used to assist suppliers in becoming deforestation-free, plus using satellite data for increasing productivity by monitoring soil moisture or other factors. By the end of the project, one unanticipated output was integrating digital data on yields and subsequent export volumes and considering against local increases in deforestation. If there was a substantial increase in output from a specific producer compared to historic yields, and illegal deforestation could be detected within a certain area, then an investigation could be triggered as to whether the increased output was from a recently deforested area being laundered into international supply chains through the existing, legal supplier.

The remainder of this section provides a narrative using participants' quotes then a summary of themes informing the theoretical review and subsequent elaboration.

Qualitative data narrative

The original voluntary cross-sector target for ZDFSC by 2020 lacked clarity from the beginning . As one company manager told us,

"*The [2020 ZDFSC] declarations were made in reaction to activist NGO campaigns on palm oil. But there was no definition of forest, so we did not know how to measure deforestation [and] we had no supply chain transparency.*" (Ref-1A)

An agriculture consultant echoed this saying, "*"Where you actually set the level for what constitutes deforestation is something that needs to have at least a definition, benchmark or agreed criteria…What definition of deforestation do users want? Is it tree cover loss? Is it illegal deforestation?"* (Ref-1B)

To build a new ZDFSC service specific measures were needed including sourcing locations, boundaries of farms and plantations, location of formally protected areas, land-tenure data, a specific definition of deforestation or degradation from a given location, the potential for seasonal changes in leaf cover and the impact of landslides, potentially giving false signals of deforestation (Ref-1Ba).

In selecting case study companies, one of the SSCM consultants, highly experienced with food sector clients, explained how the supply chain structure of different food products would affect the nature of the deforestation monitoring,

"*Soy will be compounded and comingled at an increasing level the more steps you take away from the farm gate. By the time it gets onto a ship it might be comingled for a very large geographic area indeed. Whereas something that is very specific to flavour and some other brand attributes, like coffee, that isn't going to happen, because the consignments that leave the country might be down to farm level if they are really high brand value. So we've got to be very careful not to use generalised statements about the provenance going back to farm level as that will be highly dependent on what product we are talking about.*" (Ref-2D)

This shaped the case study selection, with one being the supply chain for a prestige coffee seller, and the other being the supply chain for a supermarket with a tier 1 livestock supplier and a tier 2 soy feedstock supplier.

Across the project, a total of 15 workshops were conducted with 11 potential users, leading to 14 stated requirements that had universal agreement. Yet, there was huge variation too, as the SSCM consultant reported, "*There are some really divergent user requirements already, just from three interviews, three organisations.*" (Ref-2F).

As the sustainable sourcing manager for the coffee firm described, "*the system would have, in my opinion, to be designed in such a way that farmers can benefit from it.*" Provenance data alone was thought less relevant since sourcing was well known with regular visits to farms. Instead, interviews showed factors affecting productivity (soil moisture or even alerts about landslides blocking roads preventing crops from reaching ports) were much more sought after (Ref-5A). This then indicated an interplay between technical solution and actual desired outcome, and how specific or general these factors were, with implications for the technical build. To quote one of the agri-tech consultants, "*This seems to emphasise the importance of not hard coding the parameters of a definition into the ontology. The ontology should be based on the general principles of defining deforestation as opposed to the specifics of a given definition which could change.*"

In designing a service to help deliver ZDFSC, agreed requirements included that the service be scalable and applicable to multiple supply chains, flexible to different needs based on different contexts, and independently verifiable and accurate. This represented a potentially contradictory set of demands. Developing the technical data architecture around the archetype of the short food supply chain (SFSC) for coffee, with high transparency and data availability, the second, dispersed and opaque, complex food supply chain (CFSC) for soy, had different challenges (Ref-3C/3D/5A). See Figure 2.

Further characteristics concerned the nature of control and relative buyer/supplier power. With a supermarket as the focal firm in the soy CFSC, their relative size versus the Tier 2 international commodity traders was orders of magnitude smaller in turnover, meaning little influence to drive ZDFSC. To address this, multiple supermarkets and manufacturers considered collective action as necessary, but how any such ZDFSC monitoring system might work was an issue. As the supermarket's sourcing manager describes,

"*It's not one company that's going to solve it. It can only be solved at an industry level so there is a clear requirement for a solution, or a collection of solutions which are able to monitor, capture deforestation events and associated land use change, process them, package them send them off to the relevant interested parties.*" (Ref-4G)

However, to do this, some form of cross-industry structure would have to be created, possibly as a branch of government to ensure validity, impartiality and robustness,

"*How do we operate that system? Who operates it? Who receives the alerts? How do they process it? How is that whole system managed? Whose responsibility is it to deal with alerts that are triggered by the system?*" (Ref-4G)

Trying to create systems for monitoring, reporting and verification of material provenance prompted the notion that wider institutional support may be needed. The extent to which the Government was going to commit to driving this was unclear,

"*If it's going to be regulatory driven with a specific requirements set by a policy that's tight not loose. Then we can start to get some actual ratification, calibration, precision in there...But the other driver is if they're only doing it for reputational reasons and to put a label on the package saying 'we've checked this and it's fine'. They might be quite happy to say something that's come out of the PR [public relations] and the branding perception of it, which is potentially much looser…If legislation does come in, for certain, guarantees have to be made. Then they're going to have to get it independently evaluated."* (Ref-1H)

Hence, a regulatory driver would need institutional coordination with agreed specific standards. Since supply chains are international in nature regulatory alignment between nations may follow. In the event, lack of alignment between producer countries and consumer countries meant due diligence could consider only *illegal* deforestation, since producer

countries retain control over land-use policy as a sovereign right under international law. Hence, a data layer on legal or illegal land use was needed, including protected areas such as national parks, or data on land tenure that is often weakly recorded.

For those companies already monitoring on a voluntary basis there was an internal misalignment with their actual supply chain management performance measures. As one sustainable sourcing manager described their use of an existing system,

"*I receive an email with a deforestation alert. But what am I supposed to do with that information?*"

A ZDFSC monitoring service might be used by one part of the business, but not be part of operational processes designed to manage performance towards ZDFSC as a goal. Interviews with users noted some criticism of some existing services as demanding additional resource (cost) from the user (as client) to actually make sense of the data provided and integrate it into their systems. In a low-margin, price competitive market such as food, for ZDFSC services to not provide clear value-for-money (generate benefits greater than costs) undermined their potential. Whether benefiting the bottom line, being a reliable defence against reputational damage, or being a mandatory cost imposed on all as a result of regulation, the underlying factor was, as described by a senior policy consultant, "*These are price-sensitive industries, and while achieving a more sustainable supply chain may be technically possible, it will come at a price. If you say, this will add 5% to costs, that is seen as impossible to accept*". So while the data and technologies for greater monitoring for ZDFSC may exist, they would not be viable without some form of standardisation, based on specific measures, yet to make them valuable, specific measures were also needed.

In summary, bulk commodity food supply chains are "*horribly complicated*" (Ref-2C), with consumer-facing retailers and manufacturing brands having very low visibility and power over the upstream supply chain (Ref-1E/2C/2D), which can have many thousand producers covering a large geographic area (Ref-2D) selling through many intermediaries. Consumer-facing companies are nonetheless aware of the costs of reputational damage, which is also subject to complexity. One agri-data consultant described the challenges of assembling data for risk management, saying,

"*In order to come up, for example, with an evaluation of something as multifaceted as risk, then you're going to have to bring together data from many different providers. And with many different providers specializing in deep, different data sources and the potential for their making data available in many different ways, there's potentially a hell of a lot of complexity then for an organization looking to tap into those information sources in terms of understanding what's that data about, how do I process these different data sets?" (Ref-4B)*

The problem is both the consistency of data, but the plurality of each different client and their supply chain. Another consultant described this as two counter-acting forces of specific standards versus keeping things general and exploratory,

"*The issue of standards and agreeing standards is an area that we operate in heavily, where we have a very strong point of view that what is far more important is interoperable definitions. Standards are good, but in terms of helping people to agree on how things should be defined, if you're too broad for that standard, too ambitious, you'll hold back progress...It's about interoperable specifications about what the data is about so that you can map between standards and specifications."* (Ref-4C)

The wide range of different single, specific performance measures that could be used to develop a service, illustrated that all commodities, all sourcing locations, and all companies, had different requirements, and that standardisation would have to be co-ordinated across very wide stakeholder groups including governments.

At the firm-level, the SFSC for prestige coffee generated a relevant proof-of-concept by monitoring yield data from one farm. Here, an abrupt increase in yield over time could trigger further investigation. Monitoring adjacent forest land and detecting deforestation, might mean increase in output was from illegally expanding the area of farmed land into surrounding forest areas and effectively laundering the additional crop as from the legal farm. Replicating such a service across all farms in a given country would be a considerable effort, but one that could be technically possible, if – and only if - the costs of doing so were worthwhile.

For the CFSC in soy, the costs of effective supply chain provenance detection and even the costs of risk analysis could prompt more straightforward approaches. Cutting the Gordian Knot of the CFSC, some buyers could simply switch their procurement of soy to countries or regions that had had no risk of deforestation within the target dates provided, having converted its forests to agriculture long ago.

A further concern is that focussing on deforestation alone, could mean neglecting the wider, multiple factors of sustainable development. As described by one SSCM consultant,

"*people are focusing very strongly on deforestation, as opposed to sustainability in the broad sense. I think that…has all sorts of consequences… if you measure complexity with only one metric you get lots of perverse outcomes and my fear is that an overly strong focus on greenhouse gas emissions will lead to all sorts of bad stuff happening around the complex systems we're working in.*" (Ref-4D)

Outside of the anticipated regulation on due diligence for illegal deforestation, pre-existing regulation on disclosing the carbon footprint of supply chains was already prompting discussion on cutting imports associated with deforestation. The risk here, is that focusing on a single measure of carbon reduction was disconnected from the possible impacts on rural poverty. Given that sustainable development seeks to balance environmental conservation with social wellbeing on the basis of economic activity, a single policy driver could prompt widespread supplier deselection from particular areas. Numerous 'sustainable development goals' covering both halting deforestation and addressing rural poverty provided a wider context.

Complexity here, to the point of being characterised as a wicked problem, meant that farmers needing to maintain income could respond to supplier deselection by buyers subject to ZDFSC regulations by selling instead to 'unregulated markets'. This phenomenon, known as leakage (Moffette and Gibbs, 2021), is an unforeseen side effect of too narrow a focus on buyers achieving a ZDFSC, but for suppliers deforestation remains high and the subsequent crops are merely sold elsewhere. Therefore, a ZDFSC may be a necessary but not sufficient condition for achieving zero-deforestation (ZDF), which is the actual environmental crisis the proposed regulations seek to address.

Having summarised key themes emerging from the empirical research data, the next section now turns to a reflection on theory that the research process found relevant to the empirical case data. This then leads to abductive elaboration of that theory, as outlined by Ketokivi & Choi (2015).

5: THEORETICAL LITERATURE REVIEW

The goal to achieve zero deforestation supply chains by 2020 was stated as a voluntary target, or pledge, by the 450+ members of the Consumer Goods Forum, an international trade association, in 2015. Alongside this, the UN set Sustainable Development Goal 15.2 as 'halting deforestation' by 2030 – also a voluntary targets, but to be met by multi-stakeholder efforts across governments, business and other stakeholder organisations. The process of setting goals or targets, whether voluntary or mandatory, public sector or private, is an instance of performance measurement and management (PMM) (Bitici et al. 2012). Hence, the field of PMM is a relevant application of organisational studies to the attempt to meet targets for ZDF and ZDFSC.

As an organisation's 'nervous system', a PMM system is also a 'decision support system'(DSS) for management that helps by connecting and aligning with the organisation's structure, processes, functions, and relationships, in order to shape action (Bititci et al. 1997). With users claiming existing services were insufficiently linked to operational processes in supply chain management, and clearly involving the need to assess performance towards a pre-determined goal (ZDFSC), PMM is a relevant theoretical perspective. However, PMM scholars (Barrows & Neely, 2011; Bourne et al., 2018; Pekkola & Ukko, 2016) have noted that organisations exist in an external context that can be plagued by uncertainty and volatility, affecting their operational decision making and also making it difficult for developing strategy and an associated PMM system. This is certainly seen in the cases of the complex supply chains (CFSC) in Case 2, and such supply chains are typical of such commodities. Harkness and Bourne (2015) show that difficulties in measuring performance in a dynamic external environment, mean managers often cite complexity as a major challenge for PMM systems.

Bourne, Melnyk, and Bititci (2018) thus argue that future theorisation of PMM systems is needed that incorporates complexity. More recent developments of PMM theory include

Pavlov & Micheli (2022), who apply complexity theory to PMM, and Micheli & Muctor (2021) who look at how PMM can be adopted at the level of business eco-systems, which are constellations of firms coming together to achieve a shared goal. Other supporting work relevant to the case of ZDFSC, include Gomes et al. (2022) who consider how PMM might operate where such eco-systems include uncertainty, pointing to the need for inter-organisational learning processes. Other relevant research (Legenvre & Hameri, 2023) includes on how data sharing processes can emerge along complex supply chains. However, these papers do not address the particular challenge of sustainable supply chains as a form of complex PMM. Meanwhile, another contemporary paper, Oyedijo et al. (2023), on barriers to achieving sustainability goals across multi-tier food supply chains, does not draw on PMM theory.

Similarly, research on deforestation and supply chains includes legal studies (Grabs et al, 2021) or geography (Lambin et al, 2018; 2023), rather than management studies. Hence, we seek to conduct theory elaboration on PMM from the perspective of ZDFSC. However, we also note that papers such as Pavlov & Micheli (2023) address conditions of complexity, but do not accommodate these within a theory that also covers their counter, which is conditions of simplicity.

Here, we note the PMM model of the Performance Alignment Matrix (PAM) of Melnyk, Bititci, Platts, Tobias, and Andresen (2014), described below, and link it to parallel concepts developed in far greater depth in the management field of decision theory DT (Simon, 1947, 1972, 1973; French and Geldermann, 2005; Snowden and Boone, 2007). This addresses simple and complex contexts as being structured versus ustructured decision contexts (see also below). The PAM is a PMM model addressing alignment or ‘fit’ between a firm and its context. This novel conceptual synthesis is validated on the basis that supply chain provenance and

transparency should be considered as part of a PMM system in order to deliver intended goals (ZDFSC).

DT scholars French and Gelderman (2005) discuss complexity in relation to corporate environmental policy using the DT concept of bounded rationality (Simon, 1947, 1972). Rational decisions based on quantification, predictability and analysis (classical management science) are contrasted with those under bounded rationality, where managers either have insufficient data, or the data is too complex and changeable, for them to make effective decisions. The inability of management to gather and process necessary data with sufficient speed and accuracy to lead to effective management decision making, is a constraint to optimisation, and environmental decisions faced by management are noted for typically being un-structured. This echoes what we see in the process of constructing a service for ZDFSC monitoring, as shown in the empirical findings (above and Appendix Table C)

A fuller conceptual synthesis between PMM and DT can be undertaken by looking to Simon (1973) discussing structured and unstructured decision problems, where structured problems are clearly defined and unstructured problems lack definition; Funke (1991) later defines unstructured problems as having characteristics such as intransparency, polytely, situational complexity, and time-delayed effects.[4] In parallel, Checkland (1980) similarly complements Simon's work by distinguishing between hard systems (amenable to computation) and soft systems that emphasize multiple perspectives on the nature of a problem. Hence, in complex, unstructured contexts, different judgments based on diverse perceptions are necessary.

[4] 'Intransparency' means only some variables can be directly observed or the number of variables at work mean an observer has to select a limited number for analysis. 'Polytely' means multiple goals are present that could clash with each other. 'Situational complexity' means complex links between variables. 'Time-delayed effects' means that cause may not lead immediately to effect.

Snowden and Boone (2007) develop a further iteration of this broad dichotomy in their 'Cynefin' framework, sub-dividing structured contexts as 'simple' or 'complicated', either being known or knowable via analysis, and the unstructured into either 'complex' (mathematically unpredictable and so only retrospectively knowable) or 'chaotic' (unknowable).

To overcome bounded rationality in unstructured contexts, Simon (1947) suggests 'behavioural' factors: approximation, 'good enough' estimation, heuristics, assumptions, and judgements. Modern 'data analytics' may promise to provide management decision makers with more information, faster, but underlying complexity or unreliability of data is also a factor. The fundamental non-linearity between cause and effect make accurate prediction difficult regardless of data. Probabilistic risk analysis then informs management decision.

Returning to the PAM (Performance Alignment Matrix), this work in DT aligns with a dichotomy between 'specific' and 'general' in 'outcomes' and 'solutions'. Where things are specific they can be said to be known, and where general they are non-specific or unknown. Structured decision contexts rely on specific measurement, while a general outcome and solution call for assessment of multiple possibilities or perspectives. This parallels Checkland's call for (unstructured) 'soft systems' to be addressed via participation of those with different perspectives, which Snowden & Boone (2007) note as 'stakeholder engagement' being an appropriate management approach when faced with an unstructured, complex context.

Each of the above concepts is shown in Table 1 below, demonstrating what Tranfield et al. (2003) call 'reciprocal synthesis', different ways of describing similar concepts or phenomena. The PAM provides a relevant contrast and extension of these DT concepts, firstly as it is a PMM concept intended to overcome the challenges of complexity that traditional PMM has struggled with, and secondly because its approach does not precisely align with that of the

'reciprocal' concepts shown in Table 1. Instead, its slightly different approach offers new perspectives that can help illuminate new concepts - what Tranfield et al. (2003), call a 'lines of argument synthesis', different terms referring to different aspects of the same underlying concept or phenomenon. The next section provides a more detailed description of the PAM, and then we consider this model and its reciprocal DT terms in light of the empirical data on ZDFSC. This then enables a theoretical elaboration under abductive reasoning, leading to implications for management and a future research agenda.

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INSERT TABLE 1 HERE
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The Performance Alignment Matrix (PAM)

The PAM (Melnyk et al. 2014) has been referenced in work on systems dynamics modelling (Cosenz & Noto, 2016), complexity theory (Okwir et al. 2018), dynamic capabilities (Hasegan et al., 2018) agency and stewardship theories (Franco-Santos & Otley, 2018), supply chains (Maestrini et al. 2018), sustainability (Mura et al. 2018) and sustainable supply chains (Osiro et al., 2018) However, while these papers mention the PAM, none of these studies provide any further theoretical elaboration of it.

The PAM was developed to consider desired performance outcomes and potential solutions in relation to the notion of 'alignment' or 'fit' between internal management operations and strategic goals, and the external context (Venkatraman, 1989). How a PMM system relates to and responds to both the external environment and internal corporate strategy was needed because organisations often adjusted their corporate strategies, but with a lag in adjusting how they measure performance. Similarly, the external environment may change, affecting the

relevance of the defined measures and actions intended to improve performance.[5] The PAM categorises intended outcomes and the related solutions as either general or specific, giving a 2x2 matrix (Table 2).

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INSERT TABLE 2 HERE
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The definitions provided by Melnyk et al (2014) are as follows:

"*An outcome is a conceptualisation of an organisation's vision or goal…*

Solutions are the...approaches the organisation adopts to deliver the outcome."

This can be thought of as 'what goal is to be achieved' and 'the ways in which it is to be achieved'. The characterisation of these are then defined as:

"*General (where there is a broad understanding of what is required) …*

Specific (where the decision-maker has a fairly good idea of what is desired)" (Melnyk et al, 2014, p181)

However, the PAM does not describe in sufficient detail the processes by which a PMM should shift from specific to general in response to changing circumstances. This dynamic movement between external contexts and subsequent shift in management response to maintain appropriate fit is seen in the Cynefin framework (Snowden & Boone, 2007). This also

[5] An example might be a large retailer that rewarded the performance of managers on how well they met targets to purchase land to open new stores. However, in the wake of an economic downturn, the need for such expansion did not rapidly translate into redrawing the manager's performance criteria, on which motivations such as bonuses may be based. Similar examples of disconnect between strategy and operations can be common, and in the supply chain context may include where goods such as food commodities are purchased. In our example, the publicly stated strategic goal of achieving deforestation-free supply chains was not translated into the supply chain performance priorities of middle managers. The use of deforestation monitoring services similarly could lack sufficient integration into the performance management systems of the firm or its supply chains.

corresponds to the PAM addressing the relationship between goals and solutions as involving a level of certainty. This is akin to the known-knowable-unknowable contrasts in the Cynefin framework (Snowden & Boone, 2007). Level of knowledge (certainty) plays a crucial role in determining whether managers should provide specific or general statements regarding solutions or outcomes. When managers are certain, they should be specific in stating solutions or outcomes, whereas when there is uncertainty, they should opt for more general statements.

Furthermore, under conditions of certainty, with a specific solution to meet a specific outcome, the PAM points to 'measurement-driven-management', where performance can be controlled by specific metrics. This corresponds to the 'structured' column in Table 1 (above). This is the approach of traditional management science, which is well-suited to dealing with a stable environment where there are known, certain relationships between cause and effect. Hence, a specific solution knowably leads to a specific outcome.

Where both the solution and the outcome are instead 'general' outcomes and solutions are instead 'non-specific', and a quantitative PMM system is put aside in favour of generalities that allow a range of different solutions to emerge. This is termed, 'assessment-driven management', the assessment referring to processes of discovery, testing and consideration to determine if solutions are progressing in the direction of the generally desired outcome. Greater creativity, flexibility and exploration is needed when operating in this quadrant.

Similar to Cyenfin, the PAM suggests that under conditions without certainty (general outcome, general solutions) then 'assessment-based management' where different options and solutions are explored is needed. This is akin to the Cynefin framework's recommended response in Domain 3, 'unstructured: complex' contexts, which is to practice stakeholder engagement. Again, this also echoes Checkland (1980), 'soft-systems methodology' which is

about exploring different perspectives due to the lack of specific, clear, measurable characteristics of a particular context.

While parallels to Checkland's soft systems, or Cynefin Domain 3 are obvious here, it is also notable that being goal focused, PMM is still about seeking to reach a desired optimum of performance. By contrast, DT is concerned with the process of making a decision that leads to an action. Where the parallel concepts represent a reciprocal synthesis, the distinction between PMM and DT is an example of 'lines of argument synthesis' (Tranfield et al., 2003)

The two other parts of the matrix, where there is a mix of the general and specific in solution and outcome, point to switching between exploitation and exploration. A specific solution with only a general (non-specific) outcome (Specific Solution, General Outcome), is termed a 'solution-driven outcome', as a specific solution is employed but it is not known, specifically, what outcome it will have. This can be thought of as 'the solution looking for a problem' – a known method, without a specific goal intended. The counter to this is then the 'outcome-driven solution', where the desired outcome is known in detail, but the means to achieve it are not.

This distinction between specific and general in solutions and outcomes is clearly seen in our data, emerging unprompted but coded as such in our data analysis (Appendix Table C). We contribute to the conceptualisation of the PAM firstly by adding the various DT concepts shown in Table 1, summarised simply as the level of structure (Fernandes and Simon, 1999). As discussed by Snowden & Boone (2007), imposing specific solutions or seeking specific outcomes that do not fit the reality of the external context may lead to unintended consequences. Secondly, we provide elaboration to this model, discussed in the following section.

The PAM is about aligning the type of performance management system to suit the type of outcome it is intended to provide. This echoes work in DT about the nature of known and unknown, or structured and unstructured, decision contexts (Fernandes and Simon, 1999; Snowden & Boone, 2007), and 'fit' from contingency theory (Lawrence and Lorsch, 1967)). In developing a PMM system for SSCM in the context of forest risk commodities, where both deforestation and CFSC are known to be complex (i.e. ZDFSC), we are dealing with unstructured contexts. Meanwhile, legislation demands specific metrics (Ref-1H,), which in some jurisdictions includes the need for a burden of proof sufficient to enable prosecution in a court of law. Hence, there is a tension between the unstructured and the structured. Our case study data thus enables exploration of this tension, in order to inform a potential elaboration of the theoretical issues presented.

6: DISCUSSION AND ELABORATION

The history of the zero-deforestation supply chains agenda since 2015 can be described as typical of a market-led approach, which encourages exploration and evolution. General Outcomes and General Solutions were set, and the market response provided Specific Solutions to meet the General Outcome via technology-push exploitation. Only now that government policy in various countries is starting to engage more robustly with the issue, are Specific Solutions for Specific Outcomes being considered at scale. As noted in the findings, the act of legislation demands precision, such that non-compliance can be effectively prosecuted in a court of law (Refs 1H, 3A, 3C).

The role of government in zero-deforestation supply chains should be to define areas that are specific enough to be enforceable. The nature of evidence in a court of law is that it has to provide certainty, and so non-compliance to law or even a corporate supplier contract, demands specificity. However, excess specificity limits the scope of attention and action to such a

narrow silo that unforeseen negative effects can result (Moffette & Gibbs, 2021). To quote, Ref-4D, "*where people are focusing very strongly on deforestation, as opposed to sustainability in the broad sense...you get lots of perverse outcomes...all sorts of bad stuff happening around the complex systems we're working in.*" (See also Refs 1Ba, 4B). This clearly illustrates the concepts of a structured model of cause and effect, that lacks fit to an external context characterised by complexity and the other factors of unstructured problems (Funke, 1991).

Thus, a dynamic PMM system for ZDFSCs must balance between the Participatory Tendency, where the focus is broadened to allow additional perspectives to address complexity via emergence, and the Structuring Tendency towards specific measurement that narrows to enable direct management based on control. PMM systems for ZDFSCs must provide specific outcomes as required by legislation or other stipulated requirements, but also try to address wider considerations, including company's own PMM objectives, and the requirements of certain key stakeholders to ensure delivery of outcomes, potentially including goals such as the SDGs on addressing rural poverty by increasing exports of agricultural commodities to world markets (SDG 2, SDG 8). Impending legislation has prompted firms to address the sustainability of their supply chains, but the 'specific outcome' characteristic of legislation may also need to be balanced on a contingent basis with more 'general outcomes' found in the broader social, ecological and economic context, such as drivers around rural poverty, increasing agricultural exports, and so forth.

Coordination with stakeholders, including other firms, on such outcomes and their related performance metrics, and also with producer-country governments, may be significant in achieving the required goals of zero deforestation. Hence, to achieve food supply chains that

can make a positive contribution to sustainable development requires some innovation in how we seek to measure and manage their performance to achieve intended outcomes.

Dynamic PMM for innovative and sustainable food supply chains

Innovation was another theme emerging through the abductive research process , prompting consideration of the Wheelwright and Clark (1992) funnel model, allowing a graphical expansion on the PAM concepts of outcomes and solutions. This model dates from mass-manufacturing, where an initial large number of possible options – hence, non-specific/general -, must be focused down to a single, specific solution / outcome that would then go forward for mass production. Today, because digital services do not follow this same need for a specific outcome to be fixed into production, so new ways of considering the Wheelwright and Clark funnel model may be needed.

Solution-driven outcomes can be described as a 'solution looking for a problem', or 'technology push' as described in innovation theory (Bessant & Tidd, 2007). This is common with new technologies such as, say, blockchain, where finding useful outcomes - *exploitation* - is subject to search processes within generally defined outcomes by management. This state happens when the organisation does not have specific outcomes or goals.

Outcome-driven solutions are where a specific outcome is needed, but the solution to achieve it has not yet been determined. Hence, search processes involve the *exploration* of different solutions that can help achieve the specific outcome. This is the 'market/user pull' mode in innovation theory, and the funnel model of innovation is where a wide range of possible options are considered to meet a specific outcome. This represents one form of dynamic movement, from general to specific, representing only part of the PAM. We thus considered a fuller

incorporation of the funnel model alongside other configurations in our elaborated conceptual framework introduced below and illustrated with examples from the two case studies.

In the context of the PAM there is a key distinction between the structuring tendency and the participatory tendency. We illustrate this in the revised conceptual framework in Table 3. Similar to the initial PAM conceptual framework in Table 2, the elaborated conceptual framework in Table 3 includes level of structure (unstructured to structured), outcomes (specific and general) and solutions (specific and general). We have converted the initial framework from a 2x2 matrix into a table to enable us to include additional concepts such as descriptions, illustrations, the PMM form, the innovation stage, and the direction of dynamic change between participatory and structuring tendency.

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INSERT TABLE 3 HERE
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In Table 3, we show the PAM concepts outcomes, solutions and structure, but displayed in a line rather than on a grid, inspired by the funnel model of innovation (Wheelwright and Clark, 1992; Bessant and Tidd, 2007). In the illustrations in Table 3, we start by thinking about the desired outcomes, like goals in a system, and then consider potential solutions, described using acronyms. To design a system, you need to know what outcome it is supposed to deliver, and have PMM capable of monitoring and controlling performance towards that goal.

We do not wish to imply a linear progression from 1 to 3. Instead, 2A and 2B are alternatives, with a general direction of travel being towards 3 as the organisation transitions from a unstable/unstructured to stable/structured operating environment. The least organised, most unstructured context is represented by 1 (GOGS). The most structured, and so most organised, is 3 (SOSS). Diagram 2A (SOGS) resembles the classic funnel model of innovation in design theory, where a wide range of possible options, General Solutions, are considered to meet a

Specific Outcome, which becomes the intended design solution subsequently addressed by formal project management.

Diagram 2B (GOSS), by contrast, shows an alternative model of innovation, where a Specific Solution is known but needs to find an application – is currently associated only with a General Outcome. Without Specific Outcomes relevant to market need, such innovations can fail. Examples of success can be likened to the evolutionary principle of exaptation. This is the opposite of adaptation, where characteristics survive because they are well adapted to their external environment. In exaptation, an advantage is generated because an evolutionary adaptation later becomes useful for something else (Andriani, Ali, & Mastrogiorgio, 2017). Such 'innovation exploitation' is an example of 'solution-driven-outcomes' in the PAM.

As Outcomes and Solutions are considered, the structured and unstructured context relates to the external environment. The fundamental issue here is that, "*For PMM to be effective it has to fit the environment in which it operates.*" (Melnyk et al. 2014). Does the proposed solution fit the environment? Often this is restricted by bounded rationality, as there are limits to how much one can predict regarding external contingencies, highlighting the importance of Supply chain transparency.

In our case studies, the initial consideration of GOGS (Ref-1H) moves towards structuring (Ref-2E/3B), but then the counter tendency of un-structuring is also seen (Ref-2F/2G). The process of shifting a SOSS situation towards a more General Solution because the fit is changing was subject to considerable discussion (Ref-3H). Creating PMM systems for zero-deforestation supply chains requires search processes and questioning assumed Specific Solutions. Excessive structuring and measurement-based-management risks solutions that do not fit the context. Hence, a dynamic balancing between specific and general has to be accommodated.

Some explanatory power is provided by this elaboration on the PAM, leading to practical recommendations. In 2A and 2B the service needs skilled adapters. These are people, processes and technologies that can take solutions and adapt them towards the outcome, moving both towards Specific Outcomes and Solutions. In 3, experts in specific areas, such as in technology and processes, are needed. In 1, all-rounders with a flexible mindset and broad general knowledge are needed.

To quote from the empirical data, "*we're really augmenting the capabilities of experts for something like deforestation risk. It can so easily be spun and misinterpreted and miscommunicated, it needs to go through the lens of, in the very least, human understanding of how people will interpret the information so you need those advisors… Often here, we are data rich and insights poor*" (Ref-3F).

When outcomes and solutions are general, especially when the phenomenon under study is new or evolving, taking this approach can allow for exploring innovative solutions to transition towards 2A or 3. This role is reflected in the identified need for an analyst as a vital element in the service design for the zero-deforestation supply chains innovation project (Ref-3F).

The addition of the funnel model of innovation alongside evidence from the case studies further informs theory elaboration of the PAM regarding the nature of dynamism. Figure 3 shows the situation starting with exploration of Specific Outcome, General Solution, (2A), showing how a solution may unfold over different time periods.

CONCLUSION

The danger of being in a 'Specific Outcome, Specific Solution' domain, where measurement drives management, is that a holistic view on interconnectedness in sustainability is lost. Creativity and adaptability in decision-making that maintains responsiveness to fit the context

demands generality via the Participatory Tendency. Responsive, dynamic PMM, appreciating limits to structure, and the presence of complexity, recognises this. However, the case studies' evidence shows the need for a dynamic tension at multiple levels and stages of the project between the Structuring Tendency and the Participatory Tendency (away from structure). Our revised conceptual framework (Table 3) is an initial framing of how to manage performance across these different contexts, elaborating on how the process of designing an innovative performance measurement and management system for sustainable food supply chains must balance certain and uncertain elements.

Implications for policy and practice

This study has several implications for policy-makers and practitioners that are seeking to make food supply chains more sustainable. For policy makers, legislative efforts to make food supply chains more transparent have had varying degrees of success. This study illuminates how legislation may have unintended consequences. Legislation needs to be specific and testable in a court of law, and steering organisations towards greater measurement and sustainability reporting may be appropriate when the context is relatively structured and simple. For more complex situations, legislation may stifle the creativity and participatory approach required to solve more complex intractable sustainability problems. Legislation that does not align well with the context may also squeeze problems from one area of sustainability to another. For example, by focusing on environmental metrics to meet legislation, other sustainability areas such as unfair labour practices in supply chains may be overlooked.

This research has lessons for supply chain practitioners as well. Our study focused on soy and coffee supply chains. Transferable lessons might be appropriate for other 'forest-risk commodities' supply chains that impact on deforestation such as beef, leather, oil palm, cocoa and rubber, as well as being relevant for sustainable food supply chains more generally.

Practitioners may reflect on their specific supply chain context, the level of structure, potential outcomes and solutions, as well as the dynamism of the context and the associated management response, in order to manage performance. In some cases with relatively simple short supply chains (e.g. coffee) a structured performance management approach with clear sustainability metrics would be appropriate. In other cases with high complexity (e.g. soy), it may be more appropriate to take a participatory approach and seek the views of external stakeholders and supply chain actors, as well as have more exploration and creativity in finding solutions.

Research limitations and implications for future research

This study was limited by the scope of the innovation project and the limited time it sought to engage supply chain actors in co-creation processes. The nature of the abductive research in this paper is also focused on the PMM aspects, applied to SSCM, whereas the total data set collected includes a wide variety of other rich and interesting insights that can be developed further. These range from specific metrics, the development of data systems to be shared across multiple organisations, and how legislation is being responded to in practice and under current economic constraints.

An agenda for future research could include the following:

- more detailed analysis of specific metrics being adopted by companies, in light of legislation, and unforeseen consequences of too much structure leading to weak fit in PMM,
- more insight into specific commodities and their level of deforestation risk, including the development of landscape level approaches in Indonesia, and crops such as rubber.
- the nature of data integration and flexibility in data architectures to accommodate dynamic PMM

- better consideration of the links between specific metrics and the unintended spillover effects into areas such as human rights, addressing disconnects between different parts of corporate sustainability strategy.

Ultimately, the visions for innovative sustainable food supply chains from producer countries needs to be better imagined and detailed. What would a global agri-tech system look like that traced plants and livestock from their initial location, throughout the supply chain, to consumers? Some examples of this can be seen already, but how would such a scheme grow to the extent that food supply chains could be deemed sustainable? What additional elements, such as on soil restoration, or local livelihoods, would be needed to ensure effective and appropriate outcomes?

The role of aggregating a range of different data sources prompts attention on open architectures for data, rather than the structure of data being so specific that their information value remains siloed and only useable for the output originally intended.

Prior avenues in DT offer such new research areas for innovation in big data and artificial intelligence (advancing the potential of a Structuring approach), group decision making (advancing the Participatory), and ethical decision making, such as the values focussed decision analysis theory of Keeney (1992), providing a heuristic (Gigerenzer, 2011) to overcome bounded rationality.

Our research offers an examination of how for the complex challenge of deforestation, driven by land conversion to meet rising global food demand, prompts new forms of measurement and management. Yet delivering this as performance measurement and management systems that are focused too narrowly risk multiple potential points of failure. However, the under-regulated and uncontrolled nature of a global food sector designed to maximise production at

minimal cost has prompted commitments both within the commercial world and in governments to improve performance, suggesting potential new tools for helping to meet social and environmental challenges. We hope the concepts outlined here provide a useful contribution to understanding how such innovative and sustainable supply chains might develop further.

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TABLE 1
Reciprocal synthesis in DT concepts

Simon (1947)	Rational decision making (management science), normative (what we should do)		Bounded rationality: Behavioural decision making, empirical (what we actually do)	
Simon (1977); Fernandes and Simon (1999)	Structured decision context		Unstructured decision context	
Checkland (1980)	Hard systems (numerical analysis / management science)		Soft systems (plural perceptions on issue, therefore participative)	
Snowden & Boone (2007)	Domain 1: Structured: simple (automatic decisions/ known)	Domain 2: Structured: complicated (analytic decisions / knowable)	Domain 3: Unstructured: complex (stakeholder group decisions/ retrospectively knowable)	Domain 4: Unstructured: chaotic (instinctive leadership decisions / unknowable)

TABLE 2

Initial Conceptual Framework: The PAM, plus 'level of structure' (from DT)

		Outcomes	
		General	**Specific**
Solutions	**General**	Unstructured Assessment-driven management	Semi-structured Outcome-driven solutions
	Specific	Semi-structured Solution-driven outcomes	Structured Measurement-driven management

TABLE 3
Elaborated conceptual framework

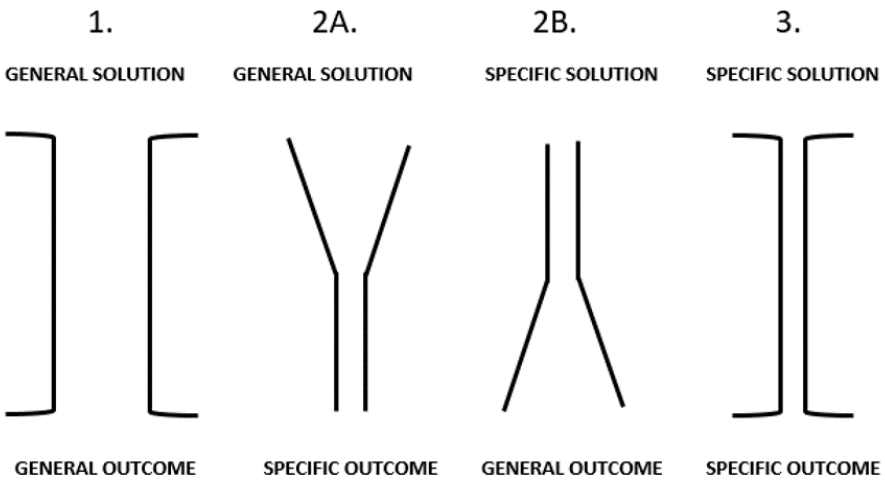
Level of Structure	Unstructured	Semi-structured	Semi-structured	Structured
Outcome (what you want)	General Outcome	Specific Outcome	General Outcome	Specific Outcome
Solution (how to get it)	General Solution	General Solution	Specific Solution	Specific Solution
Acronym	GOGS	SOGS	GOSS	SOSS
Illustration				
Description	Assessing the options and understanding the nature of the problem. Open-ended creativity through participatory brainstorming	Outcome is known, solutions general while being defined. Need a specific outcome but not yet sure how to achieve it.	Have a process that can achieve something, not sure what for yet. Exaptive tool selection	Solutions to problems well understood. Well defined system. Effective operations in a stable context.
PMM form	Assessment-driven management	Outcome-driven solution	Solution-driven outcome	Measurement-driven management
Innovation stage	Initial problem awareness	Searching for solutions	Solutions looking for problems	Obvious tool selection
Dynamism	Tendency towards structure			
	Tendency towards participation (un-structuring)			
	Participatory Tendency (PT)		Structuring Tendency (ST)	

FIGURE 1
Overview of project team and informants, including two supply chain case studies.

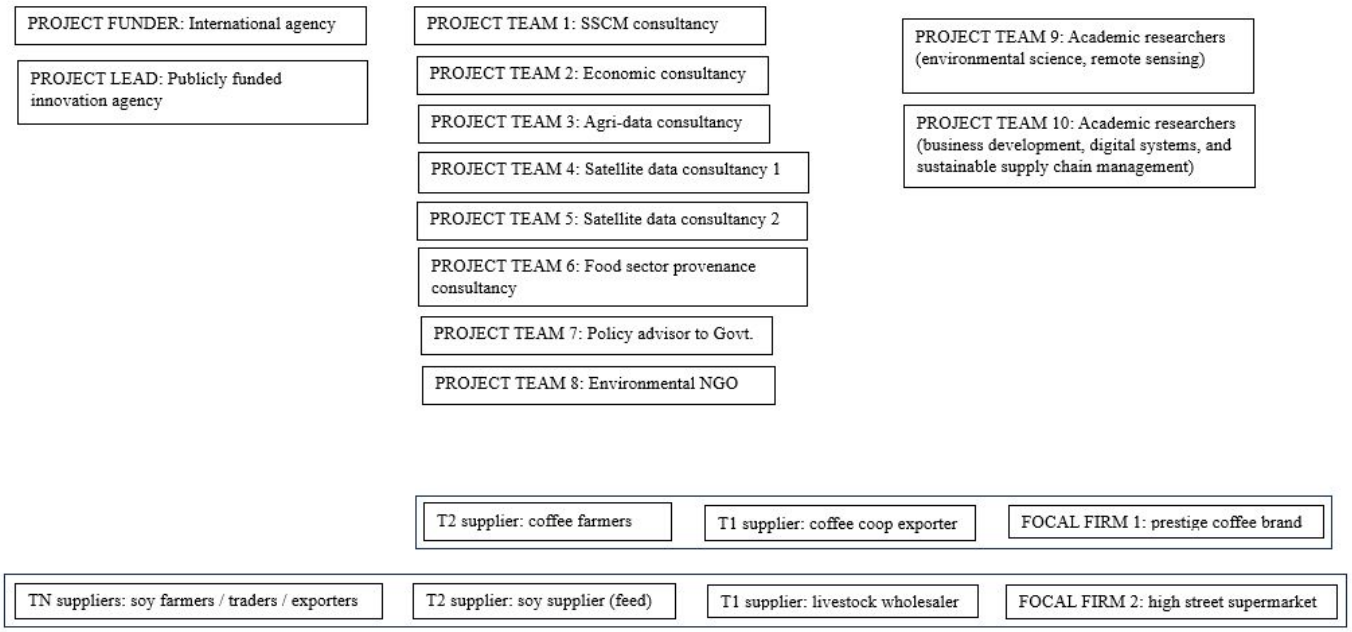


FIGURE 2
Case 1: Simple Short Food Supply Chain (SFSC), and Case 2: Complex Food Supply Chain (CFSC).

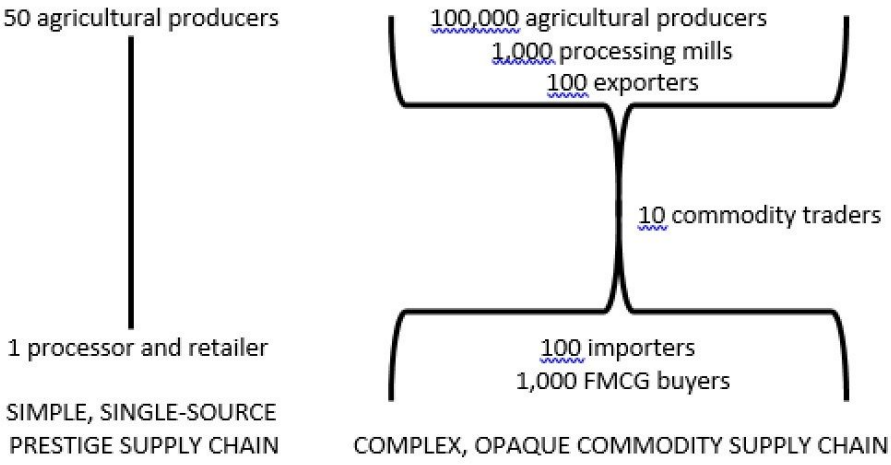
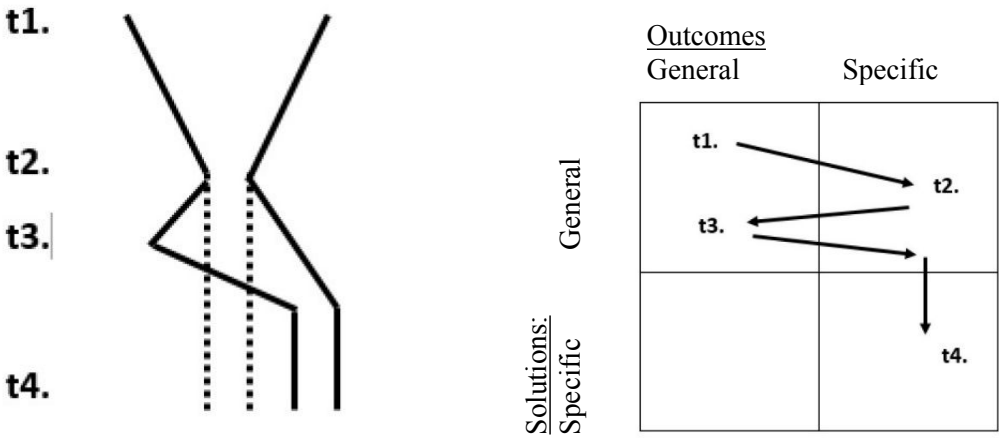


FIGURE 3
Dynamic shift from general to specific. Funnel model (left), PAM quadrants (right).



APPENDIX:

TABLE A
Indicative list of supply chain transparency tools concerned with deforestation.

Global Forest Watch (Google Earth and WRI)	USA	https://sustainability.google/projects/forest-watch/ https://www.globalforestwatch.org/ https://pro.globalforestwatch.org/
WWF Sight 2.0	UK	https://wwf-sight.org/explore/
Starling (Earthworm and Airbus)	Switzerland	http://earthworm.org/our-work/ventures/starling
Mighty Earth: Rapid Response (Centre for International Policy)	USA	http://www.mightyearth.org/about-rapid-response/
Carbon Disclosure Project supply chain / forests	UK	https://www.cdp.net/en/forests
resourcetrade.earth (Chatham House Institute for International Affairs)	UK	http://resourcetrade.earth/
IDH Sustainable Trade Initiative	Netherlands	https://www.idhsustainabletrade.com/
Forest Trends: Supply Change	USA	https://www.forest-trends.org http://supply-change.org/
ZSL SPOTT	UK	https://www.spott.org/
BVRio	Brazil	https://www.bvrio.com/madeira/analise/analise/plataforma.do
GIBBS Lab GLUE	USA	http://www.gibbs-lab.com/
Imaflora Atlas and Timberflow	Brazil	http://www.imaflora.org/atlasagropecuario/ http://timberflow.org.br/
Global Canopy Trase Forest 500	UK	http://www.globalcanopy.org/
Proforest	UK / Brazil	https://www.proforest.net/en
Ecometrica, Forest 2020 project	UK	https://ecometrica.com/
Descartes Labs,	USA	https://www.descarteslabs.com
Open Palm (Sime Darby),	Malaysia	http://www.simedarbyplantation.com/sustainability/open-palm-traceability-dashboard
RSPO Palm Trace	Netherlands	https://rspo.org/as-an-organisation/marketplace/
Geotraceability,	Canada	https://www.optelgroup.com/geotraceability-solution/
Agrotools,	Brazil	https://www.agrotools.com.br/
Satelligence,	Netherlands	https://satelligence.com/
Terramonitor,	Finland	https://www.terramonitor.com/solutions-by-industry/forestry

TABLE B
List of qualitative audio data collected.

Interviewees	Public innovation agency (Head of Agriculture, Project Manager, Business Strategy Manager, Service Design Manager)	4 hours
	Innovation consortium (service design team), including supply chain data consultants (x2), supply chain sustainability consultants (x3), NGO data experts (x2) and policy advisors (x4)	11 hours
	User-group: Sustainable sourcing managers (x8)	8 hours
Observed meetings and workshops	11 monthly 2 hour meetings with 8-15 participants, plus 2 day workshop with all above participants	22 hours 12 hours
Public speeches and presentations by consortium members	8 different presentations observed, recorded and analysed.	8 hours
Total material recorded and analysed		**65 hours**

TABLE C

Quotations referenced in the text, plus initial conceptual codes and emerging conceptual codes.

	Initial conceptual codes	Emerging conceptual codes for elaboration
Ref-1A: FMCG sustainable sourcing manager "*The declarations were made in reaction to activist NGO campaigns on palm oil. But there was no definition of forest, so we did not know how to measure deforestation. We had no supply chain transparency.*"	No definition means no specific measurement possible. Hence, general outcome, general solution state. Intransparency	
Ref-1B:Agri-consultant: *"Where you actually set the level for what constitutes deforestation is something that needs to have at least a definition, benchmark or agreed criteria…What definition of deforestation do users want? Is it tree cover loss? Is it illegal deforestation?"*	No specific measurement possible. Hence, general outcome, general solution state. Need for agreed definition	
Ref-1Ba: Agri-consult#3: "*whether we are looking at deforestation or carbon content or other measures of forest, we need different types of reference data… Specifically locations, ground plots, measurements of forest. If there's deforestation, we are simply looking at a statement of 'forest / no-forest'. So there's a lot of complexity there, and I want to raise that as we've got some requirements for ground data and it's related to your location and it's related to a choice of 'forest', or 'forest carbon', or we could also do crops as well.*"	Need for specific outcome but current situation is complex and intended outcomes still general (not specific). Need for agreed definition. Polytely.	
Ref-1C: FMCG sourcing manager#2*"we have targets to achieve 75% transparency. We are currently around 67%. Is the remaining 7% to the target extremely hard? Is the further 25% impossible? Is it that commodity markets just don't work like that?"*	Specific outcome provided. Solutions sought.	Cost of overcoming bounded rationality

Ref-1D: Policy consultant "*these are price-sensitive industries, and while achieving a more sustainable supply chain may be technically possible, it will come at a price. If you say, this will add 5% to costs, that is seen as impossible to accept*".	Specific outcome, specific solution	Cost of overcoming bounded rationality
Ref-1E: SSCM consultant: *"in any commodity you've got a broad production base that consists of some mix of smallholders and large farmers or plantations…and that goes through multiple, multiple changes until something ends up on a shelf in a [supermarket]… Generally speaking, a retailer can reach out to tier one and get information. Then it starts getting very complicated because just that tier one supplier…would have quite limited influence…*	Measurement impossible due to level of structure in SC (intransparency)	
Ref-1F: NGO policy manager: "*Solutions need to be context-specific, take into account the complexities of the deforestation front, involve multiple stakeholders and create synergies with reinforcing effects.*"	Level of structure Situational complexity	Participatory Tendency Specific outcome, specific solution *and* specific context (context specificity).
Ref-1G: Supply chain consultant: "*some of the deforestation associated commodities, like cocoa are also big brand things. So you have your [B2C] Nestle's and your Mars and they have a much closer relationship with producers than, say, a [B2B supplier] does with the soy production [for animal feed]. So you start getting quite a divergence in the agency that some of these companies have depending on what commodities, depending on if branding is a thing, and whether they're big brands, or small brands.*"	Level of structure	Context specificity
Ref-1H:Agri-Data-Consultant#2: "*If it's going to be regulatory driven with a specific requirements set by a policy that's tight not loose. Then we can start to get some actual ratification, calibration, precision in there. At the moment, I don't think there's an accurate agreed definition of what counts as deforestation, or even how much forest there is. It depends on if you measure this or measure that. It's quite amazing. But the other driver is if they're only doing it for reputational reasons and to put a label on the package saying 'we've checked this and it's fine', they might be*	General versus specific outcomes.	Measurement of one thing or another thing is a contested issue. Regulation drives Structuring Tendency (ST). (tight/specific definition)

quite happy to say something that's come out of the PR and the branding perception of it, which is potentially much looser…If legislation does come in, for certain, guarantees have to be made. Then they're going to have to get it independently evaluated.		Reputational benefit looser definition (more general).
Ref-2A: SSCM consultant "*we need to have a very flexible platform where we are very agile to change, for instance, commodity, geography, and requirement.*"	General outcomes needed, not specific.	Flexibility Context specificity Participatory tendency
Ref-2B: Supply Chain Consultant: "*There are some commodities in which the visibility is very, very limited – soya being an example. There's some commodities where it's actually pretty visible - something like bananas might be an example - and there are some where it is split. So you might have a coffee, where roast ground coffee is a mixture of not visible and absolutely transparent…*	Level of structure varies for different supply chains. (context specificity)	Structure indicates potential level of transparency.
Ref-2C: Supply Chain Consultant: *"It becomes horribly complicated and hard to talk in generalities because supply chains are so differently constructed*"	Level of structure	context specificity = need for specific outcomes
Ref-2D: SSCM consultant: "*There are specific questions, like your supply chain mapping with 1000 enhanced provenance data points, and the next one, the verification of provenance for a specific user, specific commodity. There's going to be a great deal of variation and when something is comingled – soy is a good example. Soy will be compounded and comingled at an increasing level the more steps you take away from the farm gate - by the time it gets onto a ship it might be comingled for a very large geographic area indeed. Whereas something that is very specific to flavour and some other brand attributes, like coffee, that isn't going to happen, because the consignments that leave the country might be down to farm level if they are really high brand value. So we've got to be very careful not to use generalised statements about the provenance going back to farm level as that will be highly dependent on what product we are talking about.* "	Level of structure Specific versus general	Context specificity

Ref-2E: Agri-Consultant "*We need to get down to the nitty gritty of what we are going to measure and how, and how does that satisfy the needs of the client…We need to do that very soon.*"	Needing to focus in on specific (measurement) (Structuring Tendency – pushing for structure)	
Ref-2F: SSCM Consultant "*There are some really divergent user requirements already, just from three interviews, three organisations. And there's a whole series of questions about whether we can do the whole set or whether we don't do any but just have a system that validates others. It can be any of them, and I think it's going to take some time before we know what the technology will allow us, and secondly what we want to do.*"	Need to focus out on general	Participatory Tendency
Ref-2G: Project Manager: *"we need to have a very flexible platform where we are very agile to change, for instance commodity, geography and requirement."*		Dynamism
Ref-2H: Policy Consultant: "*[there's a] German company that does high end veneers. They buy very specific logs from the Congo Basin. So, they're buying from a very high risk situation but they buy a very specific product with a very specific technical spec, which requires a very specific chain of custody, and someone over there who understands what they want. So it is worth their while financing someone in the country who can also do their due diligence. Whereas anyone who's buying anything like generic plywood, there's no way they are doing that themselves.*"	Specific outcome specific solution working for a given specific application. Essentially akin to an SFCF (but for timber). Not quite a direct link to point of production, but limited steps and good visibility.	Low dynamism, stable supply chain – single, specific product, from specific area. Simple context, suited to measurement-based-management
Ref-3A: Agri-Consultant: "*existing visibility might be completely acceptable to the end user, but it might be invisible with respect to deforestation, so in time, when the legislation comes down the road that set of visibilities they currently have is not good enough. So how would this project provide that additional visibility?*"		Role of regulation in Structuring Tendency Role of customer in driving the service.
Ref-3B: Agri-data-consultant#3: "*Without us producing a high refresh, high accuracy, high resolution product for the whole of South America, we do need locations. We need to be thinking ahead about how do we approach that*	Driving from general to specific. (ST)	Dynamism Participatory tendency (given multiple potential

when there is uncertainty? Do you go ahead and say, well we'd look at the highly likely locations and target a number of those? Build some shape blocks around that. I think we've had some good discussions with [Technical manager] and [project manager] around possible targets and obviously we look at deforestation as [other company] does so there's some potential overlap there, but we could also look at forest content as well, so we can give a measure of the value of the loss. How big was the loss? What was the carbon loss with the deforestation? I raise these as possible discussions to be had with stakeholders."		specific outcomes)
Ref-3C: Policy Consultant: "*There is a discussion about whether the EU legislation should require companies to avoid illegal deforestation OR illegal conversion of ecosystems. The NGOs working in Brazil pushing for the latter in order to protect the Cerrado. The EU line seems to be fairly strong on this - forests only, FAO definition… [South American monitoring system] finds that 87% of the Cerrado native habitat falls under the 10% tree cover (FAO definition) but if you use [existing service], it misses half off it since savannah ecosystems are so seasonally variable – you have to cover the full year or miss a lot during the dry season…*" AgriTechConsultant#1: "*This seems to emphasise the importance of not hard coding the parameters of a definition into the ontology. The ontology should be based on the general principles of defining deforestation as opposed to the specifics of a given definition which could change.*"	Specific outcome, specific solution: FAO definition of forest Additional actor input key here to highlight contradiction / impact of specific outcome definition (FAO) versus need to protect savannah biome as well as strictly defined 'forest'	Dynamism Dynamic tension between general and specific. Need to maintain general outcome / general solution, not be tied to specific definition. Participatory tendency (PT)
Ref-3D: *"a palm oil refiner and importer probably has limited influence over what happens on the ground, in the sense that their supplier base is about 4000 palm oil mills, each of those 4000 mills will accept fresh fruit bunches from a variety of large plantations and smallholders, associations of smallholders or independent small holders. So, even then there's quite a long way from [palm oil company], based in Jakarta or wherever they are, and a small holder who's chopping down a bit of forest...So although all of these people are stakeholders, the agency they have is a bit limited.*"	Description of complexity	
Ref-3E: SSCM consultant: "*actually a lot of what traceability does is huge amounts of work for*	Description of complexity	

consultants trying to discover the traceability without necessarily any impact on the sustainability of deforestation at the bottom end, and of course the process has to be repeated every few months because the supply chains are not stable, or static		
Ref-3F: Agri-data-consultant#2: "*It needs to be through the lens of an Expert Advisor and so we're really augmenting the capabilities of experts for something like deforestation risk. It can so easily be spun and misinterpreted and miscommunicated, it needs to go through the lens of, in the very least, human understanding of how people will interpret the information so you need those advisors… Often here, we are data rich and insights poor… There's also the independence side of it. If you're doing your own homework and marking your own work is it's not going to work. So, for certain things, it's going to be - it should ultimately be - legislated against, that you, for some things, cannot do the evaluation.*		Role of independent reporting function. Flexibility Role of legislation (ST)
Ref-3G: Agri-data-consultant#2: "*There was a bubble around block chain and how this will reduce our costs and this is a hammer where they were going round looking for nails to hit with it. Then they realized as a result we can implement this scenario with a blockchain capability, but we need to work on this and this and this and this and this, and we only paid for a PC. Oh, well, we'll see what more money we can find from somewhere else and so therefore there's a hell of a lot of upfront management needed in ensuring that the organizations are going into this with an understanding that it requires significant investment of time and money to see it to the other end.*	Specific solution general outcome	
Ref-3H: Agri-data-consultant#2: "*there is an opportunity then for the expert advisors with their various methods to then apply judgment and look over that, and really kind of crystallize or clarify how precisely defined even the problem statement is, and feedback on that. It's a wonderful thing if, with confidence as a consultant, you can go to your customer and say, your question is not a good question. This is what your question should be, for example.*		Dynamism Dynamic movement from specific out to general.
Ref-4A: SSCM consultant: "*companies that naturally, as part of their systems, have a degree*	Certification as specific solution	

of understanding of the provenance, so I'm talking about [specific trader] and [specific FMCG manufacturer]. They are already using Earth observation-based platforms and tools. In the case of [specific trader] they developed their own. In the case of [specific FMCG manufacturer], they use [other existing service]. For those companies that don't have visibility, they almost never use technological solutions. They're using certification, and the downside of that is they know full well that certification is not about bringing systemic change around deforestation, but it's also not really keeping their own supply chains clear, because of the rules, for example, around mass balance in some commodities. However, a) it's probably the best thing they've got at the moment, and b) it has all the co-benefits of dealing with things like forced labour and child labour and free prior informed consent, and you know all of these other things which they do have to answer questions on. So, although they know that certification is not the best way of dealing with deforestation it has lots of co-benefits.	for general outcomes. Advantages of general SFSC can use specific solution for specific outcome (level of structure is simple) CFSC uses certification (specific solution general outcome – certification is bureaucratic but linked to PMM in a limited way, often retrospective and long term)	
Ref-4B: *Agri-Data-Consultant#2 "sustainability advisory is ripe for transformation and it's far more tapping into these new data sources that enable them to have far more reliable advisory often in a far more organic way in terms of being able to derive in real time, or indirectly be derived from those information sources, rather than through laborious questionnaires and retrospective consultations. In agri-environment, in particular, the big data problem is the variety problem that in order to come up, for example, with an evaluation of something as multifaceted as risk, then you're going to have to bring together data from many different providers. And with many different providers specializing in deep different data sources and the potential for their making data available in many different ways, there's potentially a hell of a lot of complexity then for an organization looking to tap into those information sources in terms of understanding what's that data about, how do I process these different data sets?"*	Sources of complexity	Incumbent sustainability advisory practices too specific, new data technology will disrupt and transform.

Ref-4C: Agri-data consultant: "*The issue of standards and agreeing standards is an area that we operate in heavily, where we have a very strong point of view that was is far more important is interoperable definitions. Standards are good, but in terms of helping people to agree on how things should be defined, if you're too broad for that standard, too ambitious, you'll hold back progress...It's about interoperable specifications about what the data is about so that you can map between standards and specifications.*"	General vs specific again – in defence of general	dynamism The role of interoperability between different specifics.
Ref-4D: SSCM Consultant: "*in the last few years there's been quite a strong shift to where people kind of go, 'oh yes, sustainability'. But actually, really, the focus is predominantly driven by climate change - greenhouse gas emissions - and that's where people are focusing very strongly on deforestation, as opposed to sustainability in the broad sense. I think that's been quite dramatic, actually, and has all sorts of consequences… if you measure complexity with only one metric you get lots of perverse outcomes and my fear is that an overly strong focus on greenhouse gas emissions will lead to all sorts of bad stuff happening around the complex systems we're working in.*"	Climate change / carbon accounting as a single, specific measure. Net zero carbon as specific outcome, general solution.	Climate change / carbon accounting as a single, *dominant*, specific measure Net zero carbon as specific outcome, general solution, as firms are searching for specific solutions. Misalignment: if a single, specific measure like carbon is dominant, but the context (external environment) is complex, then there will be unforeseen side effects. (The model will not fit the phenomenon / the PMMS is mis-aligned)
Ref-4E: FMCG Retailer: "*it's an industry challenge…It's not one company that's going to solve it. It can only be solved at an industry level so there is a clear requirement for a solution, or a collection of solutions which are able to monitor, capture deforestation events and associated land*	Interplay between specific solutions for specific outcomes, or multiple specific	Participatory tendency

use change, process them, package them send them off to the relevant interested parties."	solutions, within a network PMMS	
Ref-4G: FMCG Sourcing manager #2 "*We're asking [suppliers] to agree to an MRV system. Now obviously that MRV system is very likely to involve analysis of satellite imagery and there's a whole huge piece of work involved with how it's structured and implemented … How do we operate that system? Who operates it? Who receives the alerts? How they process it? How is that whole system managed? Whose responsibility is it to deal with alerts that are triggered by the MRV system?* *So that's a very current topic…and it's an industry challenge exactly the same as in soy. It's not one company that's going to solve it. It can only be solved at an industry level so there is a clear requirement for a solution, or a collection of solutions which are able to monitor, capture deforestation events and associated land use change, process them, package them send them off to the relevant interested parties.* "		Participatory tendency Need for collective action by industry and government / all stakeholders.
Ref-4H: FMCG Sourcing manager #2 "*[existing service] is I think very useful and it's an excellent service at a kind of very large scale it's difficult to see how it drives any kind of on the ground action, unless you know who exactly is in that landscape, or is in that area where the deforestation has occurred. It's always been my problem with satellite based deforestation monitoring systems, you know, you just have a very high resolution image of where the forest used to be, but it didn't really help you dealing with the problem. So what we tried to do is put the supply chain data, alongside the deforestation data, so you can see it both on the same screen, but even that is not necessarily much use purely based on the data. So it's all it's all the packaging that needs to be built around it, what do you do with that data and who does what with that data… okay so I've got this data on deforestation. Whose supply chain is it? Whose concessions are these? What do we do with this data and what is the grievance procedure? Who needs this information? So all that kind of packaging work that has to go alongside the remotely sensed data is really the hard part, I think. That's a big challenge.*	Structuring Tendency (need for specific knowledge of a location)	Participatory tendency (need for stakeholder engagement) (Paradox? Or just dynamic tension between opposing forces: dynamism)

Ref-5A: Project Manager: "*Did you get from your stakeholder and user requirements anything…to try and help farmers and down at local source to make the situation better as an entity or are you getting very much we need data to enforce what we're doing?"* SSCM Consultant: "*The answer question is yes, probably about 15 or 16 quite specific requests from [prestige coffee company] about what types of information would support their smallholders I've also spoken with two of their suppliers, the co-operative and the larger farm that supplies them, and got their take on things. The thing is, it's really varied and will vary dramatically between one producer and the next, one commodity and the next. But the kind of things that that we've honed in on are things like climate risk to production in the various growth phases of coffee, things like soil fertility. Even just slope information is really useful for what farms can do to protect from landslides and risks to infrastructure, meaning road and bridge damage from floods, hurricanes and landslides.*	Move from specific to general (polytely)	Participatory tendency
Ref-5B: Policy consultant: "*Everyone is using the phrase due diligence, but there are two very distinct versions of due diligence. One is the OECD constant feedback improvement model, almost impossible to turn into law, or the financial due diligence, this is the information you need to collect and these are the steps you need to take before you make an investment decision, and that is fairly easy to turn into law but fairly hard to solve problems on the ground. It's a real high level conceptual challenge at the moment to work out how to get the best of that continuous feedback but have some framework where there are penalties for those who aren't doing the right thing."*	Contrasting versions of specific outcomes (hard law) versus general outcomes (OECD)	
Ref-5C: NGO Policy expert: "*If all your stuff is coming from a concession you own or a single block of land, then that is fairly straightforward, you just look at the satellite imagery for the last five or ten years and see how much deforestation has happened in that block. But many supply chains are much more horrendously complicated and difficult to trace, and at some point the stuff all gets mixed up in a big vat before it gets passed to the next stage in the process, and you don't*	Level of structure	'Jurisdictional approaches' as means to overcome intransparency in the supply chain.

know where your litre came from to get into that vat in the first place. There are very large challenges with this traceability approach. It is proving pretty tough and one of the workarounds is this idea of jurisdictional approaches so you if can trace back to, say, a province, if that province is clean, your stuff is clean and you don't need to know where in the province it came from. It is normally within a few miles of the farm that are the hardest to trace, so if that bit can just be in a black box so anything that comes out of [geographical region] is great, because they run a clean shop, then that province needs help to achieve that clean bill of environmental health that partly comes from investments like [forest carbon offset] payments, and support. It probably ought to partly come from investments in the companies that have significant footprints there, who could be good corporate citizens and be part of the collective action to clean up what's going on there."		
Ref-5D: NGO Policy expert: *"The demand side stuff on due diligence and cleaning up supply chains, we need to double down on. But we should only expect that will solve part of the problem. All the more so if it is only illegality that is being excluded rather than deforestation, which is obviously a live issue. The biggest thing is really that we must pay for results. If no one is going to pay for the public goods, the public doesn't get them. That's the reality here. The cost of paying for them is so much less than the cost of dealing with the fall out from climate change. It's a shame it's not happening, but that would be the biggest thing. The scaling-up for the demand for higher quality emission reductions, and from that then flows all of the sectors that need to change, be they commodities, or mining sector or domestic markets, small holder production, restoration, all those things.*	Limits to specific solutions specific outcome frame. Definitions.	Cost dynamic