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Co-producing a Research Agenda for Sustainable Palm Oil

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The rise of palm oil as the world's most consumed vegetable oil has coincided with exponential growth in palm oil research activity. Bibliometric analysis of research outputs reveals a distinct imbalance in the type of research being undertaken, notably a disproportionate focus on biofuel and engineering topics. Recognizing the expansion of oil palm agriculture across the tropics and the increasing awareness of environmental, social, and economic impacts, we seek to reorientate the existing research agenda toward one that addresses the most fundamental and urgent questions defined by the palm oil stakeholder community. Following consultation with 659 stakeholders from 38 countries, including palm oil growers, government agencies, non-governmental organizations, and researchers, the highest priority research questions were identified within 13 themes. The resulting 279 questions, including 26 ranked as top priority, reveal a diversity of environmental and social research challenges facing the industry, ranging from the ecological and ecosystem impacts of production, to the livelihoods of plantation workers and smallholder communities. Analysis of the knowledge type produced from these questions underscores a clear need for fundamental science programmes, and studies that involve the consultation of non-academic stakeholders to develop "transformative" solutions to the oil palm sector. Stakeholders were most aligned in their choice of priority questions across the themes of policy and certification related themes, and differed the most in environmental feedback, technology and smallholder related themes. Our recommendations include improved regional academic leadership and coordination, greater engagement with private and public stakeholders in Africa, and Central and South America, and enhanced collaborative efforts with researchers in the major consuming countries of India and China.

Keywords: research priority setting, oil palm (*Elaeis guineensis*), agriculture, certification, policy, stakeholder engagement, transdisciplinary

INTRODUCTION

Over the past two decades palm oil has become the world's leading produced and consumed vegetable oil (FAO, 2017). Its wide-ranging use in food, cosmetics, detergents, and biofuel, combined with a competitive market price, make palm oil and its co-product, palm kernel oil, attractive commodities. Oil palm (*Elaeis guineensis*) is native to tropical Africa, but is grown across the tropics, primarily in Southeast Asia, notably Malaysia, Indonesia, Thailand, and Papua New Guinea (Koh et al., 2011; Wicke et al., 2011; Nelson et al., 2014). More recently, oil palm cultivation has expanded across West and Central Africa (Ordway et al., 2017) and parts of Central and South America (Pacheco, 2012), driven to a large extent by the higher rates of return on investment as compared with other land uses (Zen et al., 2016). As a consequence, the crop has come to be seen as an important mechanism for enhancing the income of rural communities, tackling poverty, and supporting the socio-economic development of what are often marginal rural areas on the forest frontier (Zen et al., 2016).

Since oil palm can only grow in tropical humid environments, cultivation competes for space with tropical rainforest and its associated ecosystem services, including carbon storage and biodiversity. Accordingly, critics of palm oil development in the late 1990s and early 2000s raised concerns about deforestation (Koh and Wilcove, 2008; Charters et al., 2019), increasing greenhouse gas emissions (Carlson et al., 2012; Evers et al., 2017; Wijedasa et al., 2017), and loss of biodiversity (Danielsen et al., 2009; Meijaard et al., 2018). In response, the Roundtable on Sustainable Palm Oil (RSPO) was established in 2004, with the aim of developing and managing a sustainable certification system. Within the last decade the European Union and a variety of private and public sector organizations have initiated policies to encourage the sourcing of sustainable palm oil (European Parliament, 2014; Padfield et al., 2016). Likewise, within the same time period, the two largest producing nations (Malaysia and Indonesia) introduced their own certification schemes (Schouten and Glasbergen, 2011). Yet the extent to which these initiatives have allayed fears over the sustainability of oil palm cultivation is open to question, and the discourse around the issue has come to epitomize the complexity and controversy of development in tropical countries of the world.

Coinciding with the rise of palm oil in the global market, research interest has grown exponentially over the last three decades with 1757 peer-reviewed journal papers published in 2017 alone (**Figure 1**). However, analysis of the published articles reveals a distinct imbalance in the types of research being undertaken: biofuel and engineering topics have dominated the literature, while studies examining land use change, biodiversity, and socio-economic aspects of production and

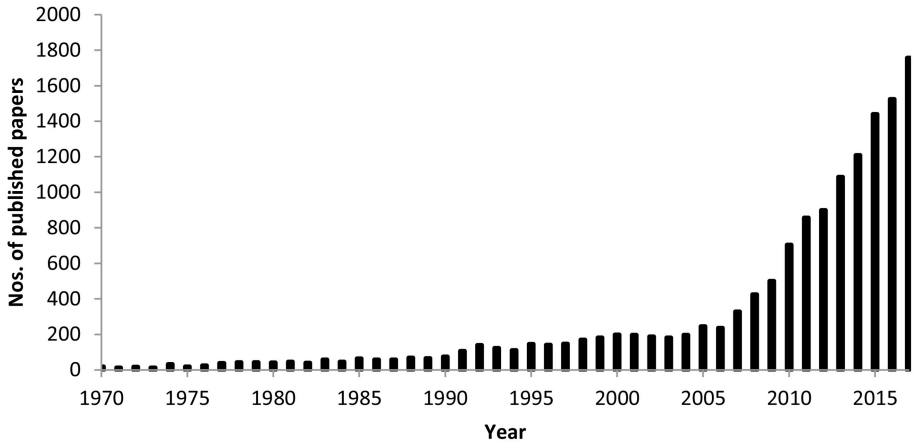

FIGURE 1 | Number of peer-reviewed journal papers published per year and indexed within Web of Science mentioning the word "palm oil" or "oil palm," 1970–2017. Source: Web of Science, 2018.

consumption are less well represented (Turner et al., 2008; Hansen et al., 2015).

The publication bias in palm oil research reflects wider trends in academia known as the commodification of knowledge and the "neoliberal university" (Peters, 2013; Jones and Jones, 2017). The commercial importance of palm oil has driven academic efforts toward production process optimization, technology feasibility studies, and product commercialization. Biofuel related topics have received particular attention from researchers working within palm oil producing countries, especially after 2000 and following the steady increase in crude oil prices (Hansen et al., 2015). Moreover, the focus on the commercialization of palm oil has directed researchers toward a relatively exclusive engagement with industrial players to address their specific research needs (i.e., plantation and mill owners, and industry associations). Thus, the normative framing of these research activities and the development pathways it proposed were strongly biased toward an entrepreneurial perspective and based on a disciplinary and technical assessment of the current situation. Despite a growing call for the integration of a broad range of disciplines and stakeholder perspectives into sustainability research (Hirsch Hadorn et al., 2008; Hospes et al., 2017), to date such approaches remain largely absent in the palm oil sector.

Recognizing the continued expansion of palm oil (Pirker et al., 2016), there is a sense of urgency to understand environmental and socio-economic impacts before irreversible damage occurs (Ripple et al., 2017; Meijaard et al., 2018). Re-orientating the existing palm oil research agenda not only matters from environmental, social, and economic sustainability perspectives, but also for the industry itself. Despite its current dominance in the global vegetable oil market, restrictive non-tariff trade policies, such as the EU's 2016 Renewable Energy Directive (European Parliament, 2016), may limit future market opportunities. A genuinely open and transdisciplinary research agenda that addresses the issues of most concern to key stakeholders will serve to demonstrate the commitment of the industry to these issues, which in turn could strengthen the industry's economic outlook.

Here, we seek to redress the imbalance in palm oil research coverage by developing a research agenda for achieving sustainability in the palm oil sector. We derive this agenda from key stakeholders as a way to re-orient efforts toward tackling the most urgent and fundamental questions. First, we identify the research priorities for palm oil sustainability as determined by stakeholders across industry, academia, government and non-government sectors. Second, we categorize the research questions generated in this exercise to determine which aspect or aspects of sustainability—environmental, social, and economic—the questions address; and the type of knowledge—system, target, and transformation knowledge—produced from the questions. Third, we examine the similarities and differences between the priority questions put forward by the various stakeholders. Finally, we recommend actions that can facilitate the uptake of priority questions by researchers and strengthen the science-palm oil policy interface.

MATERIALS AND METHODS

We employed a "co-design" approach to define research foci. Co-design of research processes and co-production of knowledge are key elements of transdisciplinary research. Transdisciplinarity is a way of conducting research that integrates and synthesizes many different disciplinary perspectives, and focuses more directly on problems, rather than the particular intellectual tools and models used to solve them (Constanza, 1991). Importantly, transdisciplinary approaches incorporate the views of various stakeholders into the research design, including the subjects of research, and others outside of academia (Constanza, 1991). With specific reference to sustainable palm oil research, Hospes et al. (2017, p. 76) champion the value of such methodology, arguing that generating transdisciplinary knowledge not only "unravels

simplified frames and black and white views on sustainable palm oil but also leads to new approaches and solutions."

Following similar stakeholder engagement studies on sustainability topics (Brown et al., 2010; Padfield et al., 2014; Seddon et al., 2014; Nagulendran et al., 2016), we integrated several modes of stakeholder consultation across three distinct phases to identify and prioritize research questions. Our approach benefited from the global reach of online surveys, which captured perspectives from a wide range of backgrounds, sectors, and geographies; structured discussions of targeted focus groups; and the intensive nature of a multi-day residential workshop. Employing diverse yet complementary engagement methods helped to draw out research questions of most importance to stakeholders participating in the study. **Figure 2** demonstrates the flow of stakeholder engagement: from the initial defining of high-level research themes (Phase 1) through to the identification and prioritization of research questions in focus groups, online surveys and the residential workshop (Phase 2), and finally the categorization and analysis of research questions (Phase 3).

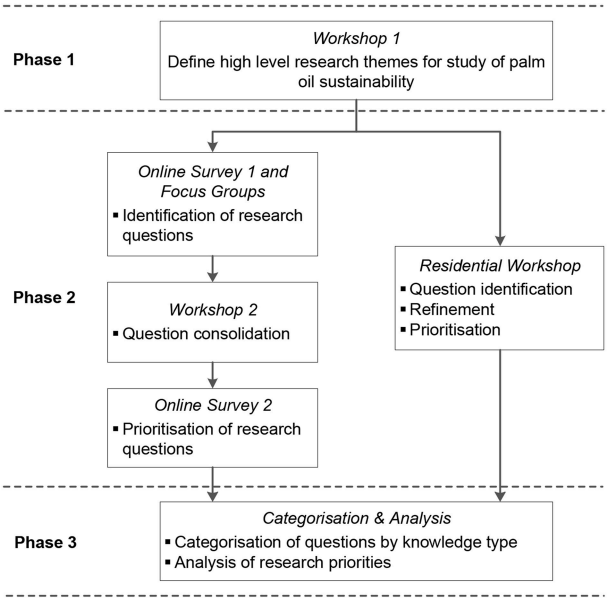

FIGURE 2 | Workflow of steps taken to generate, prioritize, and analyse research questions.

Phase 1: Defining High-Level Research Themes

As a stimulus to generate priority questions in the following consultation activities, 13 high-level research themes for palm oil sustainability were agreed in a workshop held in Kuala Lumpur, Malaysia in April 2015. Thirty-one participants from various palm oil backgrounds attended, including representatives from academia, the palm oil industry, RSPO, and environmental non-governmental organizations (NGOs). Participants operated at a range of levels: from the transnational perspective of palm oil companies and NGOs to localized levels of Malaysian grower associations and academics. Stakeholders were divided into five working groups to identify the key issues facing current and future palm oil sustainability and the types of research required to address these challenges. Each group was assigned a facilitator whose main role was to ensure each member of the group had the opportunity to participate in the discussions and to keep the groups to the workshop schedule.

Through an iterative process of small group discussions and plenary feedback sessions co-chaired by the project's two principal investigators (Padfield and Hansen), a consolidated list of 13 high-level research themes were defined and agreed by all of the workshop participants as follows: (1) biodiversity and conservation; (2) bio-based energy and products; (3) economy and supply chain; (4) feedback impacts of environmental change; (5) land use and land use change (LULUC); (6) livelihood, gender, and human rights; (7) media, communication, and knowledge exchange; (8) policy, governance, and institutions; (9) process, technology, and management; (10) resources, emissions, and environmental impacts; (11) smallholders; (12) standards and certification; and (13) sustainable consumption.

Phase 2: Stakeholder Consultation

Priority research questions from within each of the high-level themes were generated from two distinct stakeholder consultation approaches: (a) online surveys and targeted focus groups; and (b) a residential workshop involving participants from the UK and Malaysia.

Online Surveys and Focus Groups

To capture the perspectives of palm oil stakeholders from across a diversity of different sectors and countries, two online surveys were designed. The first survey (referred to as the "research questions survey") requested stakeholders to submit research questions perceived to be in most need of study to help achieve palm oil sustainability. The 13 research themes—as derived in the Phase 1 workshop—formed the basis of the survey allowing participants to submit their questions per theme. Participants were also asked to identify their sectoral background and the country in which they were based. The success of the survey relied on a "snowball sampling strategy" (Wright and Stein, 2005) whereby participants involved in the Phase 1 workshop were asked to circulate the survey to palm oil related contacts within their respective networks. In order to facilitate participation from as many stakeholders as possible the survey was open for 60 days running from 13 May to 12 July 2015.

The "research questions survey" was supported by individual focus groups with the RSPO and two NGOs, Global Environment Center (GEC) and Wild Asia. Focus groups took place within the same 60 day period as the first online survey and followed a specific protocol for interviewing in small groups, whereby interview questions were provided in advance to allow participants the necessary preparation time (Phillips and Johns, 2013). In the focus groups, participants were asked to consider palm oil sustainability issues and the type of research and specific research questions required to address these issues. The

RSPO focus group involved a discussion with eight members of the organization with experience of certification challenges facing palm oil producers in Southeast Asia, West Africa, and Central and South America. Discussion focused predominantly on the research needs of the large and mid-range sized palm oil producers as well as the needs of local communities who encounter these actors during land acquisition for palm oil. GEC and Wild Asia were invited to participate due to their knowledge and experience of livelihood and sustainability issues facing rural communities and indigenous groups in Southeast Asia, including smallholder farmers. Around 40% of Malaysia and Indonesia's oil palm area is cultivated by smallholders (Rival and Levang, 2014), yet these farmers have minimal political representation in policy circles (RSPO, 2017).

Research questions generated in the focus groups were included in the list derived from the online survey. In line with methodologically comparable studies (Brown et al., 2010; Padfield et al., 2014), the initial list was reduced by removing duplicates, comments and observations, and questions that had already been researched. To ensure integrity in the question consolidation process this exercise was undertaken by 15 researchers with knowledge on palm oil sustainability spanning hard science, engineering and social science topics. The output from this exercise was 184 research questions to be prioritized by stakeholders via a second online survey.

The second survey (referred to as the "Prioritization Survey") was circulated to those who participated in the Phase 1 workshop as a means to access their wide networks, and to those who had provided their contact details from the first survey. The prioritization process involved stakeholders identifying the two most important questions per theme (see **Table S2** and **Figure S2** in **Supplementary Materials**).The survey was open for 60 days from 4 December 2015 to 3 February 2016.

Residential Workshop

The second approach to stakeholder consultation involved a workshop held in Kota Kinabalu, Malaysia, in November 2016. As shown in **Figure 2**, stakeholder consultation in this workshop was run separately to the online surveys and focus groups as described above. The intensive nature of the multi-day workshop format created the opportunity for on-going discussion and question refinement in small and large group settings. The workshop was promoted by the British Council, the Academy of Sciences Malaysia and the international networks established in previous consultations, and was attended by 39 participants from UK and Malaysian universities, research institutions, and NGOs. UK and Malaysian researchers are some of the most active in terms of palm oil sustainability research; together Malaysia- and UK-based researchers have contributed almost half of the research outputs on oil palm sustainability, as recorded by Scopus (**Table 1**). Importantly, these two groups brought to the discussions complementary knowledge on both palm oil production as well as consumption perspectives.

We used an approach based on the Delphi technique previously applied in the environmental research sector (Sutherland et al., 2011). Prior to the workshop participants proposed key research questions via an online form. Participants were then asked to rank the questions, and the median rank of each question was provided at the workshop to inform discussions. In the first round of workshop discussions, participants were separated into groups to select 10 questions from each theme to go through to the next round, and to consolidate any repeat questions. Following this participants voted for questions iteratively, with those receiving the fewest votes removed after each round, until a final list of 94 questions was agreed upon (see **Table S3**). The highest priority question per theme was identified via a final prioritization exercise (**Table 3**).

TABLE 1 | Top five countries publishing on palm oil sustainability.

Country	No. of articles	Percentage (%)
Malaysia	774	42
Indonesia	228	12
USA	152	8
UK	121	7
Netherlands	109	6
Total	1,384	76

Number and proportion of research articles by country of lead author containing the key words oil AND palm AND sustain, 1976–2019 (Scopus database).*

Phase 3: Categorization of Research Priorities

The final phase involved categorizing the research questions produced from the stakeholder consultation exercises. Four distinct forms of categorization were performed. Acknowledging the "three-pillar" conception as the dominant interpretation of sustainability within the literature (Purvis et al., 2018), we firstly categorized each question depending on whether it addressed environmental, social and/or economic aspects of sustainability. Environmental sustainability is understood as the sustainable use, protection and/or conservation of natural resources; social sustainability refers to the well-being of individuals and communities, and the rights and needs of stakeholders; and economic sustainability refers to the financial viability and resilience of palm oil and associated industries. Questions could be assigned to more than one aspect depending on its scope and were verified by the research team.

Second, we categorized the questions by knowledge type. Hirsch Hadorn et al. (2008) identify three types of knowledge for sustainability research: (i) "system knowledge," that interrogates the origin and possible further development of a problem; (ii) "target knowledge," that determines and explains the need for change, desired goals, and better practices; and (iii) "transformation knowledge," that examines technical, social, legal, cultural, and other possible means of action that aim to both transform existing practices and introduce desired ones. As with the sustainability analysis, questions could be assigned more than one knowledge type depending on their scope and were verified by the research team. In both categorization exercises, the questions were assigned their knowledge type(s) and sustainability aspect(s) by one researcher following which

these were checked and verified by other members of the research team.

Third, a stakeholder dissimilarity index was developed in order to represent stakeholder agreement/disagreement on priority questions. The dissimilarity index was produced by deriving the average priority scores for each question by the different stakeholder groups and calculating the difference in average priority score between two stakeholder groups (i.e., by pairing all different combinations of stakeholder groups to determine the average discrepancy in priority score; Nagulendran et al., 2016). Thus, the index provided an indication of the agreement/disagreement between stakeholder groups: the lower the value between two groups, the higher the similarity in choice of research questions. Finally, the sectoral and geographic background of the participants from the various consultation activities were also analyzed.

Stakeholder Participation and Country Breakdown of Participants

In total, the study engaged with 659 stakeholders across the various consultation approaches (**Table 2**). The online surveys facilitated participation from a relatively global community (**Figure 3**), including representation from regions where palm oil is an established commodity in production and consumption terms (i.e., Southeast Asia and Europe), and where palm oil cultivation has become more prominent in recent years (i.e., Africa and Central and South America). Seven countries were most represented in the online surveys (numbers of respondents and percentage in brackets): Malaysia (208, 39.2%), UK (67, 12.6%), the Netherlands (34, 6.4%), Germany (31, 5.8%), Indonesia (29, 5.5%), USA (24, 4.9%), and France (23, 4.3%). A full breakdown of respondents by country is listed in **Table S1** of the **Supplementary Material**.

The groups with the largest representation in the study were universities and research institutes (38%), downstream manufacturers of palm oil products (22%), other (11%), NGOs (10%), and the palm oil industry (10%). In the online surveys and focus groups, the two largest groups to participate were university and research institutes (23% in online survey 1; 44% in online survey 2), and downstream manufacturers (34 and 18%), respectively. A further breakdown of the country of origin of these two groups (**Figures S1**, **S2** in Supplementary Material) reveals strong representation from Malaysian universities and research institutes, and European based downstream manufacturers. This finding is likely to be explained by the track record in palm oil related research activity by the former (**Table 1**) and the on-going interest and direct engagement by European actors, including manufacturers such as Unilever, in sustainable palm oil governance (Schouten and Bitzer, 2015).

Compared with past studies that have faced challenges in engaging with private sector actors in the palm oil industry (Padfield et al., 2014; Nagulendran et al., 2016), there was a relatively high participation from the palm oil industry in both online surveys (**Table 2**): 30 participants (12%) and 27 participants (8%), respectively. Moreover, as shown in **Table S2** we had participation from producers operating at different scales; from globally facing trans-national corporations (e.g., Sime Darby and FELDA, both of whom operate across Southeast Asia and West Africa) to nationally based producers operating in Liberia, Malaysia, Thailand, Brazil, Sri Lanka, Guatemala, and Madagascar.

Study Limitations

As compared with the other stakeholder types, there was a disproportionately high number of survey respondents from universities and research institutes (although some of these may have additional roles prior to or concurrent with their research positions). The residential workshop, in particular, comprised of 82% researchers (**Table 2**). This trend is unsurprising considering the natural appeal of research prioritization and horizon scanning exercises to the academic community. Other stakeholder types, such as consultants and government officials were under represented in the study; these two groups

TABLE 2 | Number of participants in the consultation exercises by stakeholder type.

Stakeholder type	Stakeholder consultation activities				Total number of stakeholders
	High-level research themes workshop, Kuala Lumpur	Online survey 1 and focus groups: Research question submission	Online survey 2: Research question prioritization	Residential workshop, Kota Kinabalu	
University and research institute	14 (45%)	59 (23%)	147 (44%)	32 (82%)	252 (38%)
Downstream manufacturer	0 (0%)	89 (34%)	58 (18%)	0 (0%)	147 (22%)
NGO	7 (23%)	23 (9%)	32 (10%)	3 (8%)	65 (10%)
Palm oil industry (growers, associations)	6 (19%)	30 (12%)	27 (8%)	1 (3%)	64 (10%)
Consultant	1 (3%)	16 (6%)	13 (4%)	1 (3%)	31 (5%)
Government agencies	2 (6%)	9 (3%)	13 (4%)	2 (5%)	26 (4%)
Other	1 (3%)	33 (13%)	40 (12%)	0 (0%)	74 (11%)
Total	31 (100%)	259 (100%)	330 (100%)	39 (100%)	659 (100%)

Percentages shown in parentheses indicate the proportion of stakeholder type in each activity.

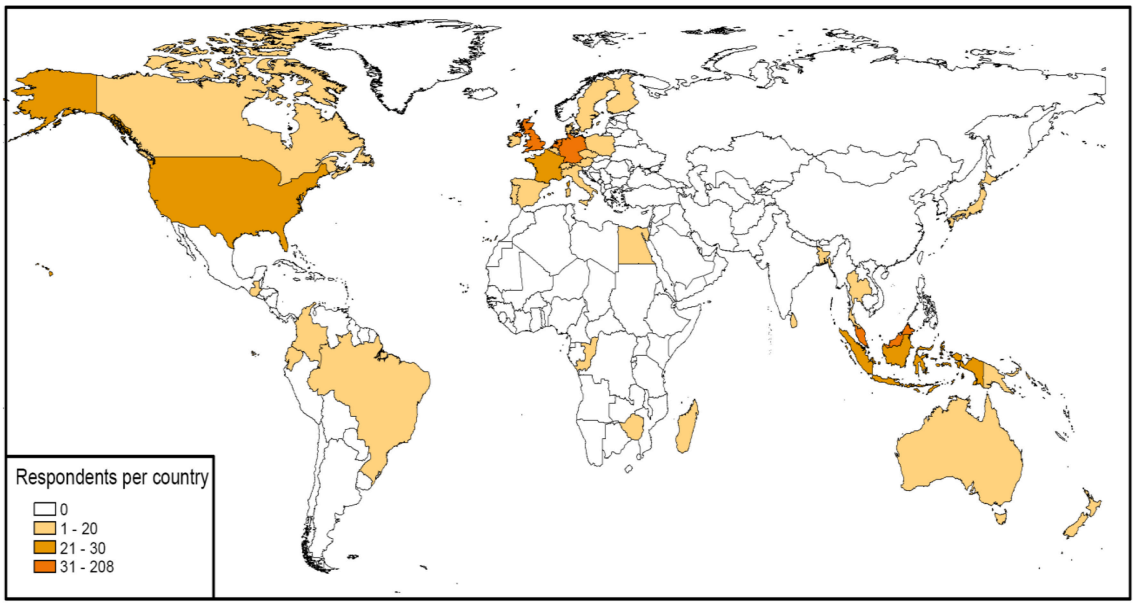

FIGURE 3 | Geographical breakdown of participants involved in the palm oil research consultation activities.

comprised of 5 and 4%, respectively of the total number of stakeholders engaged in the consultation activities. We acknowledge, therefore, that the research questions identified and prioritized are likely to represent the interests and insights of researchers more than any other stakeholder type participating in this study.

In this study, it was particularly challenging to engage effectively with palm oil stakeholders in the frontier regions, especially those located in African countries. A lack of awareness, minimal research activities and the limitation of an online survey to engage effectively with rural communities are likely explanatory factors. Furthermore, despite attempts to reach stakeholders in China and India—two of the largest consumers of palm oil—engagement from respondents in these countries was negligible. Thus, the results in our study largely represents the interests of stakeholders from two main geographic areas (Southeast Asia and Europe) and, accordingly, do not necessarily cover all of the emerging research challenges in frontier regions nor the high palm oil consuming countries in the Global South.

As acknowledged in past prioritization studies (Padfield et al., 2014; Nagulendran et al., 2016), the stakeholder reach of our surveys cannot be accurately quantified since we employed a snowball approach to circulate the online surveys. It is very likely that both surveys reached a wide audience, yet some stakeholders may have opted not to participate (Nagulendran et al., 2016). Furthermore, we have assumed that some stakeholders participated in both online surveys and thus the total number of stakeholders engaged in this study (659) does not necessarily represent 659 unique participants. Some stakeholders may also have taken a more personal view about the priority questions instead of representing the position of their organization.

RESULTS

Priority Research Questions

The online survey and residential workshop identified 279 questions; 185 generated from the online survey and focus groups (**Table S3**), and 94 produced from the residential workshop, respectively (**Table S4**). For each of the 13 themes we identified the highest priority question from each consultation approach (**Table 3**).

Research Questions Categorized by Sustainability Aspect and Knowledge Type

Analysis of the questions by sustainability reveals a higher proportion tackling the environmental and social aspects compared to economic aspects (**Figure 4**). In the online survey, the highest proportion was social (38%), followed by environmental (37%) and economic (25%). In the residential survey there was a far higher proportion of questions addressing environmental sustainability aspects—67% as compared with 21% for social and 13% for economic aspects—reflective of the high proportion of environmental researchers present in the workshop. Nonetheless, the results reveal the high priority given by stakeholders to environmental and social issues concerned with palm oil.

The main knowledge type that would be produced by answering the research questions we identified was systems knowledge (58% via the online surveys and focus groups; 62% via the residential workshop), followed by transformation knowledge (34 and 30%, respectively) and target knowledge (8 and 8%, respectively; **Figure 5**). This finding indicates that stakeholders still perceive a need for fundamental research to address knowledge uncertainties (i.e., system knowledge), as well as research that addresses how change is realized (i.e.,

TABLE 3 | The highest priority question and number of questions by theme according to the online surveys and focus groups, and the residential workshop.

	Online surveys and focus groups			Residential workshop		
Theme	**Nos. of questions per theme**	**Priority question per theme**	**Code**	**Nos. of questions per theme**	**Priority question per theme**	**Code**
Biodiversity and conservation	13	What kinds of management practices are in place by commercial plantations to ensure the sustainability of natural flora and fauna in the area of plantations, while increasing plantation productivity?	A1	29	How can we improve replanting practices to enhance biodiversity and ecosystem functioning while maintaining yield?	B1
Bio-based energy and products	13	What are the options available to palm oil producers to achieve zero-waste by generating value added by-products for energy?	A2	4	What is the effectiveness of chemical conversion technologies associated with oil palm biomass recycling on improving carbon emissions associated with agriculture?	B2
Economy and supply chain	17	What conditions and policies are required to encourage palm oil companies to switch to 100% sustainable palm oil irrespective of the market demand?	A3	3	How do the policy environment and consumer preferences for certified palm oil in demand-side countries influence demand internationally and thus impact oil palm companies?	B3
Feedback impacts of environmental change	6	How can management practices be improved to cope with impacts of extreme weather conditions, such as drought, flood events, and high temperatures?	A4	11	How does riparian buffer zone width and vegetation quality (e.g., forest structure, biomass) affect hydrology (e.g., channel morphology, soil erosion, sediment transport), river ecosystem processes (e.g., decomposition, carbon fluxes), and biodiversity?	B4
LULUC	16	How can land use and land use change best be monitored on small and large scales and published transparently?	A5	5	How can we minimize the environmental impact of the conversion of peatlands to oil palm plantations?	B5
Livelihood, gender, and human rights	17	From a socio-economic perspective, how does palm oil development affect local communities, and what tools and mechanisms are most appropriate to ensure fair distribution of socio-economic benefits to these communities whilst also protecting against any undesirable impacts?	A6	3	What are the socio-economic and demographic impacts of oil palm production on local communities once certification for sustainable palm oil has been achieved?	B6
Media, communication, and knowledge exchange	13	How can scientific knowledge (technical and non-technical) be communicated effectively to policy makers and key stakeholders across the supply chain?	A7	4	Do scientific recommendations on oil palm environmental sustainability result in meaningful changes in management practices, and how can scientists improve communication with the industry?	B7
Policy, governance, and institutions	20	What are the political obstacles at local and national levels that restrict the sustainability of the industry and how can these be overcome?	A8	4	How can scientific evidence be better incorporated into the high conservation value (HCV) approach in oil palm landscapes?	B8
Process technology and management	12	How can certification bodies, industry, and other stakeholders collaborate most effectively to develop and promote best management practices and novel technology?	A9	15	How can palm oil extraction processing be designed to reduce energy consumption?	B9
Resources, emissions, and environmental impacts	13	What are the environmental emissions and impacts of certified vs. non-certified palm oil production?	A10	5	What is the quantity of peat carbon emissions from smallholder plantations on tropical peatland and how does this compare to that of industrial plantations?	B10

(Continued)

TABLE 3 | Continued

Theme	Online surveys and focus groups			Residential workshop		
	Nos. of questions per theme	Priority question per theme	Code	Nos. of questions per theme	Priority question per theme	Code
Small holders	13	What benefits do sustainability certification schemes (i.e., MSPO, ISPO and *RSPO*) bring to smallholders?	A11	5	Are there differences in knowledge and skill levels between smallholders and larger oil palm companies, and what can be done to improve knowledge transfer between the two?	B11
Standards and certification	20	What kind of incentives are required to facilitate an increase in the numbers of sustainably certified producers?	A12	4	How can the design of certified oil palm estates be optimized to maximize biodiversity, carbon sequestration, and ecosystem functioning?	B12
Sustainable consumption	12	How does product labeling affect purchasing, procurement, consumer awareness, and consumption of palm oil products?	A13	2	How does consumer pressure for sustainably sourced palm oil vary around the world, and can this help to identify where there is a lack of public knowledge surrounding the issue?	B13

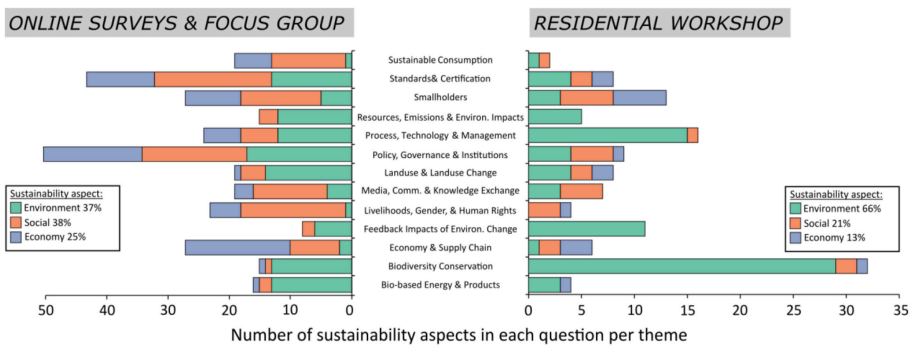

FIGURE 4 | Proportion of research questions as categorized by "sustainability aspect" in each theme. Research questions derived from the online surveys and focus groups are shown on the left and research questions derived from the residential workshop on the right. In the online surveys and focus groups the sustainability aspect as a proportion: Environmental (37%), Social (38%), and Economic (25%). In the residential workshop the sustainability aspect as a proportion: Environmental (66%), Social (21%), and Economic (13%). Individual questions could be assigned more than one sustainability aspect depending on its scope.

transformation knowledge). Despite the different methodological approaches undertaken in the two consultation exercises, the relative proportion of knowledge types represented by questions prioritized were relatively similar.

Similarities and Differences Toward Priority Questions Between Stakeholder Types

Dissimilarity scores revealed that overall, stakeholders were most aligned in their choice of priority questions across the themes of policy, governance and institutions (3.4), and standards and certification (3.8) (**Table 4**). Stakeholders differed the most in their choice of priority in the themes of feedback impacts of environmental change (8.3), process, technology and management (5.9), and smallholders (5.9). The relatively low number of questions in the feedback impacts of environmental change theme—only five questions—likely accounts for the divergence in priorities. In terms of priority preference between stakeholder groups, respondents from universities showed the highest similarity with other stakeholders. In particular, there was close alignment with downstream manufacturers (3.1), other (3.6), and NGOs (3.8).

Respondents from consultancy organizations differed the most in their priority questions against all the other stakeholder types. In particular, there was a high level of dissimilarity with the other stakeholders on the theme of smallholders. The relatively low numbers of consultants likely explains the difference in choice of priority questions against the other groups. Respondents from palm oil producing organizations and NGOs exhibited some of the largest differences in choice of priority questions. In particular, the dissimilarity score between NGOs and Producers was 7.6 (process technology and management), 7.7 (media and knowledge exchange), and 13.5 (feedback impacts of environmental change).

DISCUSSION

Emerging Research Priorities

In analyzing the patterns and relationship amongst and across the different data sets for priority questions, five priorities for

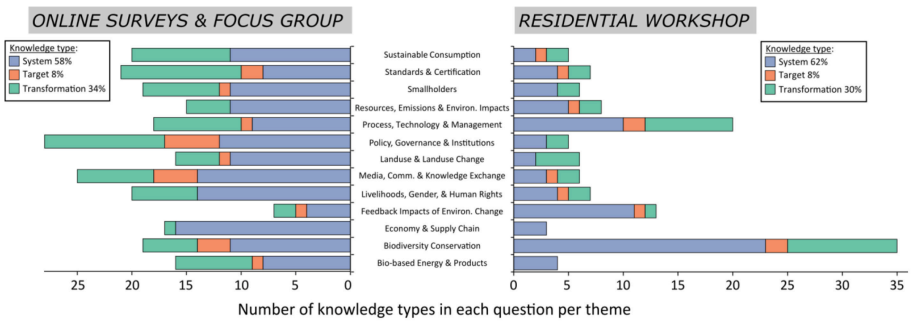

FIGURE 5 | Proportion of research questions as categorized by "knowledge type" in each theme. Research questions derived from the online surveys and focus groups are shown on the left and research questions derived from the residential workshop on the right. In the online surveys and focus groups the knowledge type as a proportion: Systems knowledge (58%), Target knowledge (8%), and Transformation knowledge (34%). In the residential workshop knowledge type as a proportion: Systems knowledge (62%), Target knowledge (8%), and Transformation knowledge (30%). Individual questions could be assigned more than one knowledge type depending on its scope.

research emerge: (i) Environmental studies; (ii) Social condition studies; (iii) Supply chain and consumption studies; (iv) Fundamental science research programmes; and (v) Improved research communication strategies.

Environmental Studies

Our research underscores a high priority for environmental studies to address the broad diversity of environmental challenges presently faced by the palm oil industry (**Figure 4**). Environmentally themed questions had a strong presence across 8 of the 13 themes as follows: (i) biodiversity and conservation; (ii) bio-based energy and products; (iii) feedback of environmental change; (iv) LULUC; (v) policy, governance, and institutions; (vi) process, technology, and management; (vii) standards and certification; and (viii) resources, emissions, and environmental impacts. Questions from these themes include those examining environmental impacts of production practices (A10, B10); ways to optimize plantation and mill management practices whilst protecting critical environmental assets (A1, A2, B1, B2, B9); and environmental benefits of sustainable certification schemes (A9, A10, A12, B12). The urgency to study and address impacts is paramount considering that ∼270 million hectares of global biodiversity hotspots could be threatened if oil palm cultivation continues to expand (Meijaard et al., 2018). This is especially relevant in West Africa, and Central and South America where the biophysical potential for oil palm expansion is greatest (Meijaard et al., 2018).

Social Condition Studies

Research questions targeting social sustainability aspects were the second largest group of questions to emerge (**Figure 4**). Evaluation of this group of questions revealed a need for research to better understand the social condition of palm oil plantations and affected communities, particularly across the following themes: (i) livelihood, gender, and human rights; (ii) policy, governance, and institutions; (iii) smallholders; and (iv) standards and certification. Example research questions include those investigating the impacts of oil palm development to local communities (B6); tools to ensure fair distribution of socio-economic benefits to these groups (A6); improving the livelihood of smallholder farmers, particularly within the context of certification (A11, A12, B11); and focus on policies and regulations to support the needs of these communities (A8, B3). Moreover, there was relatively low dissimilarity in priorities between stakeholders in these themes, particularly concerning policy, governance and institutions (**Table 4**) implying consensus across the stakeholders in our study on the need to address questions related to social condition aspects.

The need for a comprehensive social science research programme is especially pertinent in light of past studies demonstrating the vulnerability of plantation workers to exploitative practices (Fernandez et al., 2002) and documented reports of unsatisfactory working conditions occurring in plantation estates (Zudrags et al., 2015). Similarly, the social costs and benefits to oil palm smallholder communities—and nearby communities not growing the crop but affected by oil palm practices—need to be better understood in order to expand positive practices (Euler et al., 2017). Cramb and McCarthy (2016) refer to the resurgence in smallholder farming, yet there is a wide diversity of outcomes—both positive and negative—facing those entering into this farming livelihood. For example, smallholder engagement with oil palm production as either laborers, contract farmers, or small-scale producers could have varying impacts on their livelihoods and food securities (McCarthy, 2010; Montefrio, 2017). Research to better understand the impacts of oil palm on smallholders, as well as their needs, practices and experiences in oil palm production is therefore timely. Furthermore, within the social science research agenda, attention should also be paid to the inter-connectedness of the environmental and social issues, such as the practices within oil palm plantations and broader landscape transformations. An example is the unsafe handling of pesticides which can lead to health deterioration amongst the sprayers and workers (Fernandez et al., 2002; Lawani et al., 2017). Conversion of fallow lands to oil palm plantations likewise trigger social-ecological transformations that can affect the ability of smallholders to sustain their livelihoods (Montefrio, 2017).

TABLE 4 | Dissimilarity index showing levels of dissimilarity between stakeholders on research questions across the 13 research themes.

Stakeholders Themes		Biodiversity and conservation	Biobased energy and products	Economy and supply chain	Environmental Feedback	Land-use and land-cover change	Livelihood, gender, and human rights	Media, communication, and knowledge exchange	Policy, governance, and institutions	Process technology and management	Resource, emissions, and environmental impacts	Smallholders	Standards and certification	Sustainable consumption	Average
Consultants vs.	NGOs	5.8	6.9	4.0	8.1	7.6	5.9	8.1	3.9	7.1	7.1	9.4	5.6	5.9	6.6
	Manufacturers	5.8	6.8	4.0	6.3	7.6	5.9	7.4	4.1	4.8	5.7	9.4	5.5	7.3	6.2
	Producers	3.8	6.5	6.3	8.1	6.6	5.9	6.4	4.2	7.3	6.8	12.1	5.5	5.4	6.5
	Gov't	6.4	7.2	6.4	6.0	7.8	5.9	6.0	4.6	6.6	7.4	12.0	4.3	7.7	6.8
	Universities	4.3	5.6	4.8	3.7	6.5	5.9	7.0	3.7	4.2	5.4	10.1	5.3	5.5	5.5
	Other	5.6	8.0	4.9	5.1	6.3	5.9	7.9	4.4	7.1	6.6	8.0	4.7	6.0	6.2
NGOs vs.	Manufacturers	4.3	5.7	3.5	10.4	3.4	3.3	4.0	3.2	6.7	4.5	2.2	3.3	6.2	4.7
	Producers	5.2	6.4	3.6	13.5	4.2	4.3	7.7	3.0	7.6	5.1	4.6	3.4	5.3	5.7
	Gov't	3.2	5.2	4.0	10.9	3.3	5.2	4.4	3.3	5.8	5.4	5.8	4.1	5.8	5.1
	Universities	2.7	4.4	3.2	7.0	2.6	4.5	3.5	3.0	5.5	4.4	2.5	2.6	3.7	3.8
	NGO-Oth	4.1	3.2	1.9	10.1	3.9	3.8	4.1	3.7	4.9	2.9	4.3	2.1	4.1	4.1
Manufacturers vs.	Prodcuers	5.8	4.0	3.3	11.2	3.9	4.8	6.1	3.0	6.0	3.6	3.8	4.3	4.2	4.9
	Gov't	3.8	5.6	5.2	9.3	4.3	4.4	4.1	3.4	4.3	5.8	5.3	5.1	7.9	5.3
	Universities	3.4	3.0	3.1	6.2	3.0	3.6	2.7	1.6	3.3	2.2	1.7	2.7	3.4	3.1
	Other	2.2	6.3	4.1	8.6	4.7	3.4	3.7	2.9	5.3	4.0	3.8	2.9	4.4	4.3
Producers vs.	Gov't	5.0	7.8	4.7	11.1	4.0	3.6	5.8	4.4	6.5	7.1	5.1	3.7	5.5	5.7
	Universities	3.6	4.1	3.0	9.8	3.8	3.4	5.0	3.1	4.7	3.8	2.8	2.9	3.0	4.1
	Other	4.5	7.0	3.9	7.1	3.3	2.4	6.9	3.3	8.0	4.7	5.8	2.6	3.8	4.9
Gov't vs.	Universities	3.0	5.3	3.3	7.3	2.8	3.4	4.3	3.1	5.4	4.8	4.4	3.9	5.2	4.3
	Other	2.5	4.9	4.9	9.4	4.1	3.2	4.7	3.7	7.6	6.3	7.3	4.2	5.8	5.3
Uni's vs	Other	2.5	4.4	3.3	5.1	3.4	3.3	4.3	2.5	4.3	4.2	4.2	2.1	2.7	3.6
Average		4.2	5.6	4.1	8.3	4.6	4.4	5.4	3.4	5.9	5.1	5.9	3.8	5.2	

The orange cells are the highest decile (i.e., top 10%) of the dissimilarity values; the blue are the lowest (bottom 10%), with the remaining gray cells are the 80% of values around the median.

The low degree of dissimilarity amongst stakeholders on policy and certification related research themes also implies a general agreement between stakeholders to include policy orientated studies as part of the overall effort to address social and environmental concerns. The highest priority question in the policy and governance theme in the online survey and focus groups ("*what are the political obstacles at local and national levels that restrict the sustainability of the industry and how can these be overcome?*" [A8]) has received little research interest to date. In order to address sustainability concerns related to palm oil, research should incorporate a combination of different disciplines across different scales of study (local, national, international) whilst also including policy, governance and certification related approaches.

Supply Chain and Consumption Studies

Despite the limited attention afforded to supply chain and consumption related studies to date (Hansen et al., 2015), the findings from this study suggest stakeholders perceive this topic to be an important research priority for the future. In the Phase 1 workshop, stakeholders identified and agreed upon "sustainable consumption" and "economy and supply chain" as two of the thirteen themes for the following stakeholder engagement activities. The online surveys and focus groups, and workshops returned 34 questions across these two themes (**Table 4**), 29 of which were generated from the former. While small in number compared with the environmental and social condition research questions (**Figure 4**), the inclusion of these two key themes and the subsequent questions submitted in our study—in view of the limited attention given to this topic by past researchers—implies these topics are of growing importance to stakeholders.

To date, few studies have investigated supply chain and consumption aspects, despite the likely impact this will have on the future of the palm oil industry (Gassler and Spiller, 2017). This research theme focuses on the end user (i.e., the consumer), as well as the processes of palm oil procurement in value chains, including the role played by various actors in the value chain (Oosterveer, 2015). The paucity of research may in part be explained by how "hidden" palm oil is as an ingredient compared to other commodities, such as coffee and cocoa. The substitutable nature of the crop makes it valuable for many uses, yet it is difficult to trace in a value chain (Borras et al., 2016). One study of consumer preferences in Indonesia found that there was a low understanding of the environmental and social impacts of palm oil, yet there was a degree of interest and willingness to pay for products containing certified sustainable product (Daemeter Consulting, 2015). Similar studies in the major importing countries, particularly in under-researched nations such as China and India, would generate new knowledge and inform policymaking and communication strategies by key industry stakeholders.

Fundamental Science Research Programmes

Analysis of the knowledge type of questions revealed a high proportion of systems and transformative knowledge (**Figure 5**). This finding implies stakeholders believe there to be a need for fundamental science research programmes across a variety of topics, and research in consultation with non-academic stakeholders to develop "transformative" solutions. Interestingly, there was a far lower proportion of target knowledge questions explained by two possible factors.

First, stakeholders were not asked explicitly to consider target knowledge questions, such as "*what is sustainable palm oil production in your view,*" or "*where should the palm oil industry move to in the next 10 years.*" Second, there were likely *a priori* assumptions at play concerning the desired goals and expectations of what constitutes a sustainable future amongst participants in the consultation. Such assumptions focus on questions that address current issues (i.e., systems knowledge) and actions to be taken to achieve a sustainable future (i.e., transformation knowledge), but rarely reflect on what the goal or target should be (i.e., target knowledge). The challenge here is that the concept of "sustainable palm oil" means different things to different people at different points in time. Without a reasonable level of agreement on the meaning of this concept amongst stakeholders, transformation efforts are likely to lack focus and be met with resistance.

This point is illustrated by the progression of certification systems for palm oil. For example, Bessou et al. (2017) found that visions of sustainability and global challenges varied greatly among palm oil growers and other stakeholders in Indonesia and Cameroon, with implications for the implementation of good practices. Similarly, the RSPO consultation process has been criticized for its mechanistic approach and absence of value or moral questions. Ponte and Cheyns (2013, p. 471) argue that despite the wishes of smallholder farmers to include principles of justice and civic values in the RSPO standard, dialogue between stakeholders was largely "technical… and the need for moral responsibility was relaxed to focus on the 'here and now.'" Whilst this example demonstrates the way the RSPO consultative process is designed to meet the needs of corporate actors, it underscores the difficulties in attempting to reconcile differing views of "sustainable palm oil." Applicability of academic research into the industry is likewise directly linked to a common understanding of the target. Thus, the lack of target questions identified by participants within our study underscores the importance of developing improved understanding on how assumptions differ between stakeholders.

Improved Research Communication Strategies

The final priority is the need to improve communication strategies to facilitate the uptake of research findings into practice and policy, as well as measures to support better collaboration between stakeholders. Analysis of the highest priority questions from both the online surveys and focus groups, and the residential workshop under the media, communication and knowledge exchange theme (**Table 4**) highlighted a specific need to improve the communication of research outputs, particularly to non-academic stakeholders (A7, B7). Pullin et al. (2013), Stringer and Dougill (2013), Sutherland et al. (2010), and Laurance et al. (2012) have all made similar arguments in relation to the adoption of scientific findings in environmental topics. Stringer and Dougill (2013, p. 328) argue that within the context of research in sustainable development: "there remains a pressing

need for greater reflection on the practical enablers allowing research to better support policy."

Within the palm oil sector there are a variety of possible explanations for the current science-policy impasse. One broad explanation is the general disconnect between research, policy, and practice, which is common in academia where career advancement is focused toward academic outputs (Lucey et al., 2017). Hansen et al. (2015) observed that the application and assimilation of research outputs from Malaysian universities into the palm oil industry has been minimal despite a significant rise in locally authored academic papers since the early 2000s. One possible reason is the lack of translation of academic research into a form accessible to policymakers and practitioners. Knowledge mediators, such as non-profit think tanks and scholars themselves who are open to transdisciplinary and translational work, can do such translations. There is also a greater role for "pracademics;" academics who act as trainers, advisers, and consultants with NGOs (Stevens et al., 2014). Pracademics traverse both academic and practitioner domains with relative ease and thus are well placed to articulate the key scientific findings between academia and practitioner stakeholders. Such efforts, however, tend to be overlooked or disregarded in an increasingly competitive and neoliberalizing higher education system. Greater recognition of knowledge exchange and research impact activities in recruitment and promotion criteria within academia would help to overcome the relatively exclusive focus on traditional academic outputs, such as journal articles and monographs.

Another likely explanation is the perceived risk of data publication by the palm oil industry, commonly experienced in other sectors and industries (Tartari et al., 2012). A number of growers have increasingly engaged researchers in certain aspects of palm oil production and specific ecological and wildlife studies, such as the Sime Darby Foundation's on-going investment in the Stability of Altered Forest Ecosystem (SAFE) programme in Malaysian Borneo (https://www.safeproject.net/) and the SMART Research Institute funded by a large palm oil company, Golden Agri-Resources (https://goldenagri.com.sg/sustainability/smart-research-institute-smartri/). It should also be noted that research programmes involving large plantation firms are often established out of necessity; companies with RSPO certification are required to monitor their high conservation value forests. In general, companies engage in sustainability research for instrumental and business case reasons, such as for enlightened self-interest to improve practice so that they can access product more effectively and/or to ameliorate impact so that they can protect reputation. Some companies may be forward thinking in terms of anticipating future problems, but ultimately they are constrained in their engagement because they are involved for private rather than public interest. Thus, in order to embark in basic applied research themselves, companies need the assistance of scientists to train their teams, identify the questions and deliver the answers to these questions. Despite the various university-industry collaborations, and notwithstanding the difficulties in achieving access more broadly across the agri-food sector, gaining meaningful and long-term access to oil palm plantations, mills, and migrant worker communities remains an ongoing challenge.

Steps Toward a Sustainable Palm Oil Research Agenda

The identification of priority research questions and themes are useful, but by themselves do not necessarily mean they will be taken forward by researchers or incorporated into future research programmes. Following on from the emerging priorities as stated above, we recommend four action points to further develop the palm oil sustainability research agenda. These action points reflect a growing recognition in academia that research activities should have clearly defined societal benefits and impact as well as conventional academic outputs, such as journal publications (Lucey et al., 2017).

Regional Academic Leadership and Coordination

There is a need to develop strong research networks in those regions most active in palm oil research—mainly, but not exclusively, Southeast Asia and Europe—with a view to strengthening the academic voice on palm oil issues and help overcome the current science-policy impasse. Such networks can facilitate international and cross-cultural research collaborations with an aim to address the specific questions raised in future research endeavors. Hansen et al. (2015) have previously called for the establishment of local and international collaborative partnerships. Similarly, the World Bank recommends better collaboration and coordination within palm oil research fields (World Bank Group, 2011). In 2014, the Academic Research for Palm Oil Sustainability (ARPOS) network (https://www.facebook.com/arposnetwork) was established in Malaysia, yet has limited involvement from researchers outside of Malaysia. Drawing on the experience of exemplar global research networks e.g., the Society for Research into Higher Education [https://www.srhe.ac.uk/networks/international_research_and_researchers] and the Global Health Network [https://tghn.org], a European researcher network aimed at circulating research updates, funding calls and organized information knowledge sharing activities would be timely. These regional networks could then interact more closely to strengthen links between the main palm oil research regions. There is a role to be played in terms of supporting researchers in regions where palm oil is making a more recent impact (Africa, Central, and South America) and the largest consumer countries (India and China). A stronger voice from academia can also constructively influence public and private policy-making and inform broader public perceptions of palm oil.

Encouraging Knowledge Co-production and Transdisciplinary Approaches

This recommendation highlights the need to develop a culture of transdisciplinarity within universities and research institutions with a view to ensuring palm oil research projects have applied as well as academic outcomes. Building on growing recognition of the benefits of participatory research methods to address socio-ecological challenges (Karimi et al., 2015; Moore et al., 2017; Turreira-García et al., 2018), this recommendation aims to create

all three knowledge types (systems, target and transformative) in partnership with non-academic stakeholders in order to change existing practices and introduce desired ones. Importantly, stakeholders should be encouraged to take up a role in the co-production of knowledge throughout the research process itself. The priority questions we identify address the needs of various stakeholder groups, from the large corporate actors with considerable resources and influence to the less powerful and less visible smallholders and associated groups. It is critical for researchers to recognize who are most affected by practices in the palm oil sector and work directly with these groups to explore how research can meet their needs. An example of such practice is The Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) programme, which sees scientists working closely with plantation firms to support the development of improved oil palm management and industry-compatible biodiversity surveys and guides (Foster et al., 2014). Drawing on the experience of a 5 year transdisciplinary research programme on the topic of "sustainable palm oil" between the Netherlands, Indonesia and Thailand, Hospes et al. (2017) argue that transdisciplinarity can be fostered by inviting key stakeholders to act as research advisors during the design phase as well as appointing such stakeholders as postgraduate researchers on the project.

Establish a Coalition of Collaborators

Moving away from the tradition of academics working in relative isolation from non-academic stakeholders, a useful aim would be to develop a "novel coalition" (Bulkeley, 2005) of various actors and partners in different palm oil producing and consuming regions. For example, a European based research network could engage downstream users of palm oil (i.e., manufacturers, supermarkets, catering firms), palm oil developers, industry associations, European Union parliament policy makers, lobbying groups, and NGOs. The relatively strong engagement from downstream users in this study, particularly from European based manufacturers (**Table S2**) indicates the high potential for future collaboration. An objective of dialogue with these groups would also be to discuss where these actors might invest in future research based on the priority questions. Here, one of the major challenges will be to communicate why and how academic research can benefit non-academic stakeholders, including the palm oil industry.

Acknowledging the considerable role played by smallholders in the palm oil industry, yet the relatively limited opportunity they have to influence research programme design, we also recommend researchers develop active partnerships in order to embed their knowledge and needs into the research process. Existing smallholder collaborations, such as ones developed by the NGOs *Wild Asia, GEC,* and *Solidaridad* in Indonesia, Malaysia, and Ghana could be a good starting point for collaboration. Collaborations could also be developed with social enterprise organizations, such as *Traidcraft* who have experimented with the concept of *FairPalm* in West Africa (Dyer et al., 2014). Engaging smallholders via an NGO, as has been undertaken in our exercise, is useful but should be seen as a one-off; more integrated and imaginative attempts are required if the "voice" of this group is to be incorporated into research designs. One approach is to engage directly with farmer associations that have some form of membership structure rather than proxy organizations that represent farmer interests but are not owned by the farmer. This recommendation should also be open to possibilities of on-the-ground coalitions (e.g., smallholder associations and NGOs) to devise their own research agenda in collaboration with academic partners, i.e., community-based research.

Improve Accessibility, Communication, and Availability of Research Findings

In response to the perceived weak science-to-policy interface and poor communication of research outputs to non-academic stakeholders, reviews, and meta-analyses of published research are clearly needed together with broader communication of research findings beyond academic or industry silos. Dissemination strategies include circulation of policy briefs that summarize the main research findings in local languages, knowledge exchange workshops with key stakeholders and adoption of the latest stakeholder communication strategies, such as mental models (Biggs et al., 2011). This recommendation also extends to the availability of knowledge generated by industrial research institutes. These institutes conduct their own research programmes on sustainability related topics yet much of this is largely unknown in the academic community since it is not published in academic journals. It is either used only within the company itself or published in industry related literature and reports. Moreover, in view of the increasing transparency of land use operations afforded by recent developments in digital mapping technologies and online platforms (e.g., *World Resources Institute's* Global Forest Watch online tracking tool) it is timely for companies to collaborate more openly with universities and research institutes. Such an approach would reflect positively on the companies themselves whilst allowing researchers detailed insight into land use change and related aspects. For those working in palm oil sustainability related fields, there is a need to make research more widely available by either capacity building within the respective research institutes to help them analyse and publish more widely or by making the gray literature itself more available. The formation of a coalition of collaborators could also allow translational work to be undertaken with the assistance of knowledge mediators. Non-profit organizations and think tanks can help translate the publications of their academic partners for policymakers, industry players, and even farming communities.

CONCLUSIONS

Despite an intensification of palm oil research activity in the past three decades, the integration of a broad range of disciplines and stakeholder perspectives in the design of these research endeavors has been limited. The commercial importance of palm oil combined with a growing neoliberal trend in academia toward the commodification of knowledge has led to a relatively exclusive engagement with research that meets the needs of a small group of industrial players (Hansen et al., 2015). An alternative research agenda that

aims to tackle the complex interplay of environmental, social, and economic aspects would not only have potentially wide-ranging societal benefits, but can also serve to strengthen the economic outlook of the palm oil industry. Through a process of stakeholder consultation we have found a particular need for research across a wide range of topics—environmental and social aspects being the most prominent—and for fundamental science programmes and improvements in research communication strategies. Furthermore, in view of the high degree of consensus regarding the need and priority for research addressing the top 26 questions identified in this study, we hope and anticipate that these questions will soon be addressed by the palm oil research community. Palm oil researchers should continue to engage relevant stakeholders in the industry, and integrate their perspectives throughout the research process.

ETHICS STATEMENT

This study was undertaken with the approval of the respective Research Ethics Boards (REB) at the School of Anthropology and Conservation, University of Kent and at the Malaysia Japan International Institute of Technology, Universiti Teknologi Malaysia. All participants in all activities gave written informed consent to participate in the study and intention for publication in accordance with the Declaration of Helsinki. Information linking participants to research questions prioritized or not prioritized was not collected. Figures have not been published elsewhere.

AUTHOR CONTRIBUTIONS

RP, SH, ZD, JB, ES, and MS conceived the ideas, and planned the paper. RP led the phase 1 workshop, online surveys, and focus groups. MS, ZD, ES, JL, and JB led the residential workshop. RP led the writing. All authors contributed to the drafts and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/ffgc.2019.00013/full#supplementary-material

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