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Transnational corporations and the challenge of biosphere stewardship

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Sustainability within planetary boundaries requires concerted action by individuals, governments, civil society and private actors. For the private sector, there is concern that the power exercised by transnational corporations generates, and is even central to, global environmental change. Here, we ask under which conditions transnational corporations could either hinder or promote a global shift towards sustainability. We show that a handful of transnational corporations have become a major force shaping the global intertwined system of people and planet. Transnational corporations in agriculture, forestry, seafood, cement, minerals and fossil energy cause environmental impacts and possess the ability to influence critical functions of the biosphere. We review evidence of current practices and identify six observed features of change towards 'corporate biosphere stewardship', with significant potential for upscaling. Actions by transnational corporations, if combined with effective public policies and improved governmental regulations, could substantially accelerate sustainability efforts.

Consolidation among corporations, whereby a small number of companies control a large market share of the overall output or sales for a particular product or product type (that is, oligopoly or, at the extreme, monopoly), is a well-known[1,2] and predictable[3,4] feature of economic development[5]. Some 10% of the world's corporations generate 80% of all profits globally[6]. A handful of transnational companies (TNCs) in the information technology sector control 90% or more of the global market share of search engines, operating systems and social media[7]. Three investor firms manage over 90% of all assets under management in passive equity funds[8], and retailers, which form the interface between consumers and global supply chains, also show high levels of concentration[9,10]. Such dominance is variously explained by increasing share of returns from growth going to capital rather than labour, the ability of TNCs to navigate regulatory systems opportunistically across multiple jurisdictions, and their capacity to create barriers to entry for smaller firms[11].

In fact, the scale at which TNCs operate, and the speed and connectivity they galvanize across the world is unprecedented in history[12]. TNCs have become a defining feature of the interconnected planet of people and nature[13], with humans as a hyper-dominant species in the biosphere affecting global patterns of ecological change[14,15]. While concerns have been raised about industry dominance in relation to the environment[16,17], others argue that inclusion of corporations in international agreements, like the Aichi Biodiversity Targets, could be beneficial for all[18].

Voluntary TNC sustainability commitments are essential and can translate into improvements[19], but so far, many private-sector supply chain initiatives for sustainability fall short on several fronts[20–23]. Overall, the past two decades of efforts to leverage supply chain power of major TNCs have failed to meet the expectations for improved sustainability[24,25]. Conversely, government regulations and international agreements have not been able to meet the growing need to regulate the complex dynamics of an intertwined planet[26] with human dominance as a major force shaping it[27,28]. Understanding and acting upon the new dynamics of the Anthropocene is fundamental for human well-being, and TNCs clearly are part of it.

Here, we focus on the link between dominant TNCs and the biosphere and explore whether such dominance can be acted upon to serve as a leverage towards sustainability. We recognize that small and medium-sized enterprises also play a key role, but many such enterprises are either part of TNCs' global supply chains or serve a domestic market only[29]. Drawing on empirical observations from

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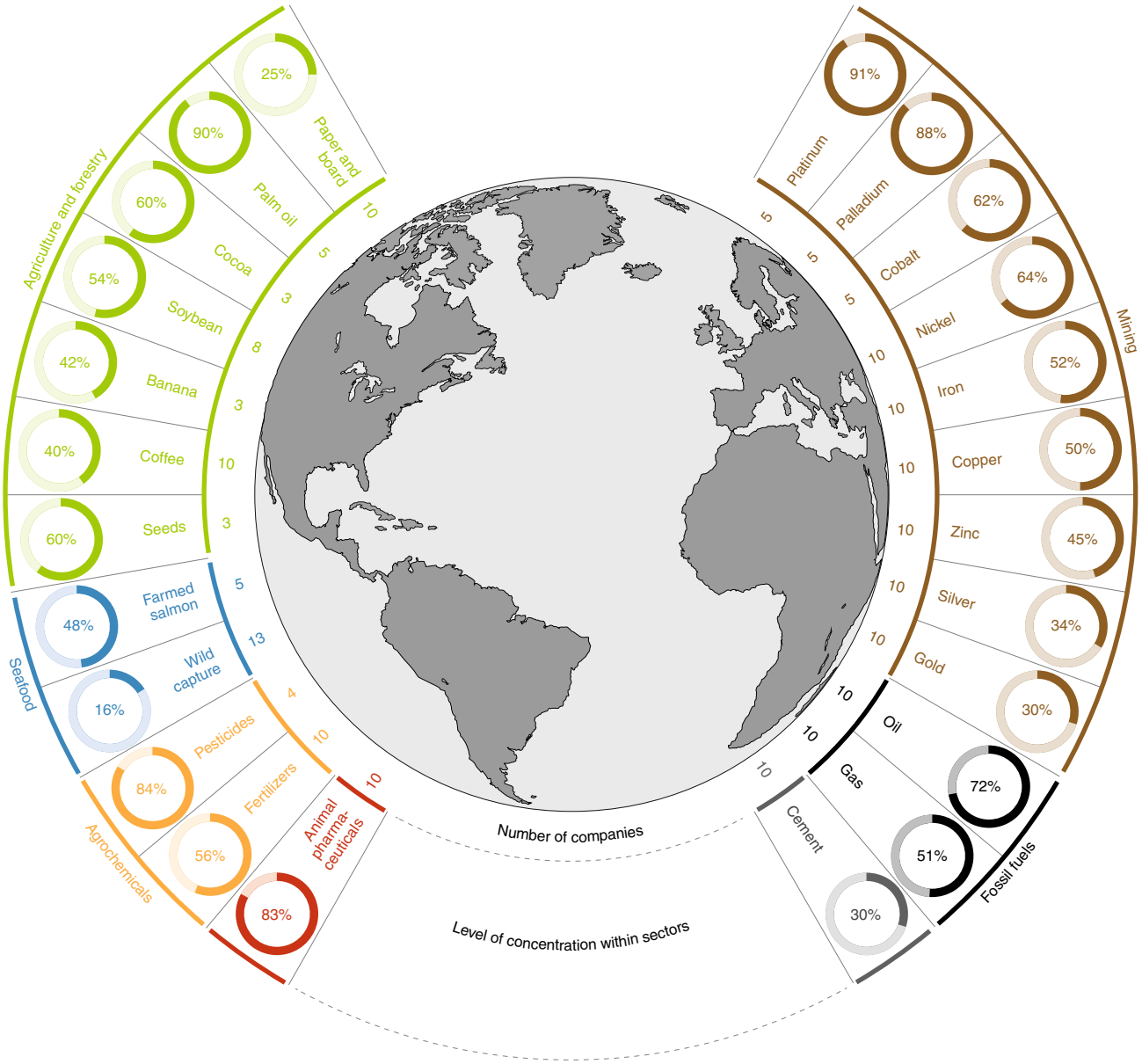

Fig. 1 | The biosphere in the hands of a few. Transnational corporations have become a major force shaping the world's ocean, atmosphere and terrestrial biomes. Based on available data, the figure illustrates estimated levels of concentration for industries shaping the biosphere. Concentration is measured as, for example, proportion of profits or sales, market share, exports, production, trade volumes or access to resource reserves. We use these measures, rather than a consistent economic percentage of sector dominance, to illustrate the disproportionate capacity of TNCs to influence large-scale material flows and processes. The consolidation described here is assumed to be associated with an ability to influence standards, practice and norms in the respective industry in relation to the capacity to shape the biosphere. See Tables 1 and 2 for details on each estimate, source material and a synthesis of industry-related environmental impacts.

diverse sectors, we identify six features at the interface of science–business–society that are stimulating systemic change towards sustainability. Together with effective policies and regulations, these features may provide building blocks for shifting dominance towards biosphere stewardship and a safe operating environmental space for humanity[30].

Shaping the biosphere

A handful of TNCs have a major direct or indirect influence on the world's ocean, the global atmosphere and terrestrial biomes, system components that serve critical functions in Earth's dynamics (Fig. 1 and Table 1). TNCs dominate harvesting of the largest and most valuable fish stocks, including species with important functions in ocean ecosystems[31]. The same is true for the world's forest capacity to regulate Earth's climate[32]. About 70% of greenhouse gas emissions are attributed to 100 companies, including both TNCs and state-owned monopolies producing coal, oil and gas[33]. These companies disproportionally influence climate change and ocean acidification. Sectors that generate contaminated effluents, with impact on ecosystems and biodiversity, show similar dominance (Table 1).

TNCs have also become central in the development of the global food system, a major driver of environmental change, through simplification of landscapes, loss of biodiversity, release of greenhouse gas emissions, and alteration of biogeochemical and freshwater

cycles[34,35] (Table 1). Following recent mergers and acquisitions, the fertilizers market, the global agrochemical industry and the commercial crop seed market are dominated by ten, four and three TNCs, respectively. The same is true for ten corporations engaged in animal pharmaceuticals (Fig. 1). The observed levels of consolidation in the food system are also striking for individual commodities such as coffee, banana, cocoa, soy, palm oil or farmed salmon (Fig. 1 and Table 2). Mega-merger trends continue to drive consolidation vertically and horizontally within and across sectors, borders, systems and the land–ocean interface[36,37], with dominant companies being often interlinked and interdependent.

Clearly, TNCs are central actors in the human-dominated world and possess the ability to influence critical functions of the biosphere. This global keystone actor dimension of TNCs[31], whether producers, suppliers or financial actors, should be recognized, accounted for and governed in efforts towards sustainability within planetary boundaries[38,39].

TNCs and sustainability

Reality presents us with dominance[40] and the environmental time window for transforming human actions towards sustainability is shrinking[28]. In this context, could the power of dominant TNCs help leverage large-scale systemic change[41], accelerate positive transformations towards sustainability[42] and contribute to a safe operating environmental space for humanity[30]?

In the face of insufficient environmental agreements and regulations, dominance poses a threat to sustainability. For instance, companies able to set barriers to entry in a sector can stifle sustainable practices and technological innovation in general. They can also impose low prices on suppliers, which reduces suppliers' capacity to diversify and can force them into monocultural practices (particularly in the agricultural sector). Finally, TNCs often lobby regulators to weaken environmental and social standards to the benefit of their own businesses[43–45].

More generally, there exists scepticism towards businesses as sustainability leaders given two decades of relative ineffectiveness of voluntary corporate social responsibility[25,46]. Market concentration and corporate power are often regarded as roadblocks to social progress given the business priority of economic profit over non-market values[24]. Concerns have also been raised about viewing business as the solution to the problems they themselves took part in creating[24]. Also, emerging TNC sustainability initiatives have been questioned as they do not challenge the underlying imperative of business growth[47].

On the other hand, should dominant TNCs impose effective sustainability standards throughout their supply chain, this could influence both upstream and downstream market actors, including small and medium enterprises. This was the case when the world's largest retailer committed to certified seafood, which is thought to have catalysed other retailers and triggered a rapid increase in certification[48]. Hence, as dominant actors impose sustainability measures, behavioural changes may propagate throughout global markets. Over the past two decades, 250 to 300 pioneering companies have actively invested for sustainable development, followed by several thousand other companies integrating sustainability considerations in their business[49].

Reputational risk management represents an important part of corporate strategy, particularly for large household-facing brands that are vulnerable to naming-and-shaming campaigns[16,50]. Such exposure helped realize the corporate sector soy moratorium, which contributed to reduced deforestation in the Brazilian Amazon[51]. The World Wildlife Fund has consequently worked to influence companies with the greatest impacts on commodity demand, with the aim of shifting entire markets towards corporate stewardship of biodiversity, water and climate, and reducing the impact from commodity production on key areas of importance for global conservation[52].

However, TNC leadership is unlikely to be sufficient unless governments also provide a regulatory context that safeguards non-market ecological and social values. Antitrust law and institutions have a central role to play in regulating dominance and keeping markets competitive, but they are ill suited to address concerns associated with public governance of goals like environmental sustainability or with the political power of large corporations[53,54]. Importantly, the delineation between public governance and large corporations is increasingly blurred[55]. Private governance is rapidly emerging in a range of biosphere-related sectors[56,57], where TNCs play a big role in shaping their own regulatory space[58] including how sustainability is defined and enacted. Concerns have been raised over such increasing influence, particularly with respect to accountability, fair representation and global equity[16]. In this context, major changes in the strategy and practice of TNCs are needed to help shift power away from being exercised to the detriment of sustainable use of the biosphere[24].

Towards corporate biosphere stewardship

Are we starting to observe the beginnings of such a shift? Action is urgently needed to stabilize the Earth system within conditions favourable for humanity[28] and rising awareness of the dependence of the global economy on the biosphere foundation[59] is creating incentives for rapid innovation in business strategy and practice[60]. Although the primary goal of TNCs is not to produce for the common good, different incentives have led some progressive companies to increasingly engage in substantive sustainability efforts[16,56].

We call attention to six observed and emerging features of systemic change in the public–private policy interface towards biosphere stewardship. The six features reflect the engagement of large TNCs in major change processes and illustrate how public and private environmental governance regimes could enhance each other since they rarely operate independently[20]. Examples include TNCs active in biosphere-related sectors (Fig. 1 and Tables 1 and 2) as well as in other sectors from which inspiration could be drawn.

Alignment of vision. Mindsets and values across society are now changing, recognizing that global environmental change concerns the viability of humanity's own future. There is mounting evidence that new norms are emerging among some of the largest brands[16] and corporate initiatives are achieving intensity reductions of greenhouse gas emissions[56]. Fifty-two per cent of a sample of some 450 companies in the food, wood-products and textile sectors that are listed on the 12 largest OECD (Organisation for Economic Co-operation and Development) stock exchanges, use at least one sustainable-sourcing practice[46]. The most progressive CEOs of TNCs often represent role models for entire sectors and play a disproportionately large role in challenging established norms and developing new visions. They also serve to inspire a generation of new sustainability-minded entrepreneurs. In parallel, pressure by non-governmental organizations, consumers and investors lead to more socially and environmentally responsible firms. Broadening the value base from profit only to responsibility, ethics, and creating meaning and purpose is a sign among large TNCs of a potential shift from compliance to conviction with the ambition to become a positive force in sustainability transitions[61]. The United Nations (UN) Global Compact (a voluntary initiative of CEO commitments to implement universal sustainability principles and to take steps to support UN goals), and the World Business Council for Sustainable Development, serve as learning arenas for directing business practices towards sustainability and for generating ecologically coherent innovations for biosphere stewardship.

Mainstreaming sustainability. Society needs guiding frameworks to define a problem space, within which innovation can flourish to find sound solutions. Global political agreements like the Sustainable

Table 1 | Global estimates of degree of concentration for industries directly and indirectly impacting the biosphere

Sector	Concentration	Environmental impacts	References
Agrochemicals	Four companies control 84% of the pesticides market and 10 companies account for 56% of the fertilizers market (2014)[a,9]	Agrochemicals have been linked to environmental hazards, including global warming, surface and groundwater contamination, marine eutrophication, and stratospheric ozone depletion. Insecticides and fungicides have negative effects on biodiversity and can give rise to pesticide-resistant organisms. Toxic waste is generated during phosphate fertilizer mining and production. Nutrient runoff from agriculture leads to water pollution, algal blooms and biodiversity loss. The increase in reactive nitrogen leads to the production of tropospheric ozone and aerosols, and to the acidification of freshwater. The energy cost of producing and transporting fertilizers is high.	81–86
Animal pharmaceuticals	Ten firms account for 83% of the global market (2014)[9]	The staggering use of antibiotics in food production in both terrestrial and marine environments is approaching grave limits and antimicrobial resistance is becoming a serious issue in relation to human health. Veterinary medicines can also affect terrestrial and aquatic systems. For instance, carcasses of livestock that were medicated with a non-steroidal anti-inflammatory drug were found to be toxic to raptors.	84,87–89
Commercial seeds	Three companies control 60% of the commercial crop seeds market (2014)[a,9]	Patented seeds undermine local practices to select, produce and exchange a variety of locally appropriate seeds. Such standardization of the food supply decreases species diversity at the global level and thus reduces the resilience of the food system.	90–92
Mining	Five companies account for 91%, 88% and 62% of the world's platinum, palladium and cobalt production, respectively. Ten companies produce 64% of nickel, 52% of iron, 50% of copper, 45% of zinc, 34% of silver and 30% of gold global production (2015–2017)[93–98]	Effects of the mining industry include habitat destruction, air pollution through the release of unrefined particles when mineral deposits are exposed from the site, loss of biodiversity, soil erosion, land subsidence, formation of sink holes, water and soil contamination caused by leakage of chemicals or trace metals, as well as noise pollution, air blasts and vibration from blasting. The disposal of extensive mine wastes further contributes to air, soil and water contamination with consequences on local communities, livestock and wildlife biodiversity.	99–101
Fossil fuels	Ten companies control 72% and 51% of the world's proved reserves of oil and gas, respectively (2014)[102]	Fossil fuels are the largest source of anthropogenic emissions of carbon dioxide (CO_2), heavily contributing to climate change and its consequences on biodiversity. Fossil fuel extraction leads to deforestation, ecosystem destruction and chemical contamination of land and water. Oil spills negatively impact both terrestrial and marine ecosystems. The refining process results in toxic air and water emissions, and hazardous waste. The combustion of fossil fuels also creates air pollution.	103,104
Cement	Ten companies produce over 30% of the world's cement (2017)[105]	With about 8% of global CO_2 emissions, cement is the second-largest single industrial CO_2 emitter in the world. Its production requires a great amount of energy (fossil fuels), produces greenhouse gas emissions and releases air pollutants such as mercury, sulfur oxides and nitrogen oxides.	106,107
Forestry	Ten companies account for 25% of the total paper and board production (2015)[108,109]	Different forms of forest management have different impacts on climate and biodiversity integrity, two critical features of biosphere stability. Forest management that does not account for changing climate is risking large tracts of forests burning, releasing large amounts of CO_2 into the atmosphere in pulses and losing large carbon storage capacity for decades to come. Such effects may cause detrimental climate impacts. Plantations can lead to habitat conversion, deforestation, soil erosion, altered water cycles and pollution from agrochemicals. Pulp and paper manufacturing is also one of many industrial sources of emissions of sulfur and nitrogen oxides.	110–113
Seafood	Thirteen companies control 11–16% of the global marine catch and 19–40% of the largest and most valuable stocks (2012)[31]	Overfishing can provoke the collapse of wild fish stocks and associated marine ecosystems. Fishing causes bycatch and habitat destruction. The reliance of the aquaculture sector on marine ingredients for feeds further increases pressure on wild stocks. The growing use of antimicrobials in aquaculture generates antimicrobial resistance.	31,89,114–116

Sectors exhibit different levels of consolidation, measured as for example, proportion of profits or sales, market share, production, trade volumes or access to resource reserves. Values are based on best available data from the referenced material. [a]2014 figures were used to compute market share but taking into consideration mergers and acquisitions that happened later in 2017.

Development Goals (SDGs) or the Convention on Biological Diversity are examples of normative frameworks that are defined by science but can be magnified by engaging with corporations[18]. In 2017, four in ten of the world's largest companies engaged with the SDGs in their corporate reporting[62]; in a sample from 2018, more than 70% of some 730 global companies mentioned the SDGs

Table 2 | Global estimates of degree of concentration for various commodities directly and indirectly impacting the biosphere

Commodity	Concentration	Environmental impacts	References
Palm oil	Five companies account for approximately 90% of global palm oil trade (2015)[117]	The clearing of land and forest to allow for palm oil production has severe environmental consequences associated with deforestation, habitat degradation and climate change. Monocrop plantations have been mostly created at the expense of biodiversity-rich primary tropical forests. Soil erosion and water pollution from palm oil mill effluent represent further issues.	111,118,119
Cocoa	Three companies control around 60% of the world's cocoa grindings (2013)[120]	Intensive cocoa plantations negatively impact biodiversity through the conversion of natural forest areas, use of chemicals and forest degradation even in agroforestry systems. The processing of cocoa beans also results in organic waste.	111,121
Soybean	Eight companies control at least 54% of the processing or exports of soybeans (2011/2015/2016)[a,90,122,123]	Soybean production is highly dependent on inputs such as fertilizers, pesticides, fuels and land. Forest conversion and the destruction of wild habitats (mostly outside of the United States and Europe) in favour of plantations lead to biodiversity loss.	111,124,125
Salmon	Five companies account for 48% of global farmed Atlantic salmon (*Salmo salar*) production (2017)[126]	Environmental impacts of salmon aquaculture include competition and genetic introgression of escaped farmed salmon into wild populations; local and regional pollution from chemical inputs, organic loads and nutrients; sea lice (*Lepeophtheirus salmonis*) and disease transfer from farmed salmon to wild populations; pressure on wild fisheries for feeds; and antimicrobial resistance.	111,127
Banana	Three companies control 42% of global banana exports (2013)[128]	Large-scale commercial production of bananas leads to conversion of natural forest areas to plantations, soil erosion, high pesticide use, and pollution of soil and water. Banana production also results in organic and plastic waste. Banana processing (washing and selecting) uses large quantities of water.	111,129
Coffee	Ten companies process almost 40% of all the coffee consumed worldwide (2012–2013)[130]	Conversion of natural forest areas to full-sun coffee plantations causes biodiversity loss and soil degradation, notably due to the high use of pesticides and herbicides. Coffee processing also has negative impacts on water quality in rivers.	111,121,131,132

Sectors exhibit different levels of consolidation, measured as for example, proportion of profits or sales, market share, exports, production or trade volumes. Values are based on best available data from the referenced material. [a]United States data: 2011. Brazil data: 2015. Argentina data: 2016. Country shares data: 2015/2016.

and 27% included them in their business strategy[63]. The UN 2015 report *Transforming Our World: The 2030 Agenda for Sustainable Development* encourages partnerships between governments, civil society and the private sector to mobilize action and resources for global sustainability[64]. Creating incentives (for example, through regulations and market initiatives) for companies to enable such transformative change represents a promising approach to rapidly scale up sustainability successes[16,48]. Sustainability is no longer perceived as a choice for progressive companies — it has become institutionalized and increasingly recognized as a necessity.

Licence to operate. Transformative change towards biosphere stewardship can be facilitated by clarifications of a corporate global license to operate in a democratic, ethical and sustainable manner. Governments increasingly mobilize to regulate TNCs in this direction[58]. For example, the United Kingdom's Modern Slavery Act requires companies to disclose measures adopted to address slavery and human trafficking. The French Corporate Duty of Vigilance Law (adopted in 2017) created a legal requirement for large companies to identify and prevent abuses on human rights and the environment related to their activities and those of their subsidiaries, subcontractors and suppliers applied to entire global supply chains[20]. This law concerns TNCs with at least 5,000 employees in France or 10,000 employees worldwide. Large TNCs are predominately headquartered in the United States, China, the United Kingdom, Japan, France and Germany. Alignment of direct national transparency regulations from these countries could effectively equate to a 'corporate global licence to operate' and further stimulate TNCs to take on a leadership role before regulations are in place.

Financing transformations. Sustainability concerns are gaining attention from the financial sector[65]. Major pension funds and other institutional investors are starting to redirect capital away from unsustainable practices and towards biosphere stewardship. The UN Global Compact Action Platform for the Ocean aims to develop a business leadership framework to promote the well-being of the world's ocean. This platform supports a wide membership of large TNCs from fisheries, aquafeeds, mining and the finance sectors, including a major Nordic Government pension fund which, for instance, recently divested from companies involved in unsustainable palm oil production. Another example is the Impact Management Project that involves large financial actors to develop and facilitate consensus around shared fundamentals for how impact is measured and managed, to contribute to sustainable development. The Equator Principles, established in 2003, and Principles for Responsible Investment, founded in 2005, provide guidance for responsible investment[66]. Such coalitions, combined with recent high-level statements and strategies from individual major financial actors (for example, banks, insurance providers and pension funds) represent important starting points. Similarly, recent moves in the United Kingdom towards making environment, society and governance considerations mandatory parts of fiduciary duty, represent another indication that change is accelerating[67]. However, many of these efforts are still in their infancy and their impacts on the ground remain unclear. Ultimately, for transformative change to happen, investors and traditional financial services will need to systematically incorporate sustainability criteria into their practices and develop new norms in service of biosphere stewardship[65].

Radical transparency. Novel technologies are dramatically enhancing transparency within and among TNCs, as well as throughout supply chains that are central to the operation of TNCs[68]. For example, open access database platforms with information on all fishing vessels carrying an Automatic Identification System (AIS), along with smart algorithms to identify vessel behaviour, have radically improved global monitoring of fisheries[69]. Similarly, complex global trade flows are becoming increasingly traceable and transparent thanks to novel technologies (www.trase.earth). The CDP Supply Chain programme, which assesses the climate, water and deforestation impacts of the supply chains of large corporate purchasers, has in 10 years grown to 115 major organizations with over 5,500 top-tier global suppliers engaged. These large public and private sector organizations can lead effective change by using their substantial procurement expenditures as a powerful lever for action towards biosphere stewardship, cascading good practices and commitments further down the supply chain (https://www.cdp.net/en/research/global-reports/global-supply-chain-report-2019). By embracing and promoting such transparency, TNCs can minimize risks in their supply chains and contribute to system-wide stewardship norms, while ensuring corporate accountability. If dominant actors engage in radical transparency, they will stimulate other companies to follow their lead. A few very large TNCs have recently adopted B Corps certification and have thereby committed to independent assessments of their social and environmental performance, accountability and transparency (www.bcorporation.net). Such commitment could ensure that the global licence to operate is maintained and would further stimulate enforcement and monitoring of less transparent companies.

Evidence-based knowledge for action. Scientists, as knowledge brokers, increasingly facilitate and monitor transformative change by connecting evidence-based knowledge to action through dialogue and collaboration[70–72]. The scientific community can independently investigate and define the problems using rigorous methods, while also engaging in co-production of knowledge with TNCs to ensure that co-designed solutions address the problems, operate in line with the SDGs, and make business sense[73]. Such action arenas represent an increasingly important space for scientists to engage with in order to address global challenges while helping hold corporations accountable and stimulating them to take on a larger responsibility for the planet and develop leadership in sustainability[74]. For instance, the science-based organization Seafood Business for Ocean Stewardship (SeaBOS, www.keystonedialogues.earth) was collaboratively developed by scientists and the largest TNCs in the seafood industry with the ambition to stimulate transformative change towards sustainability and stewardship of the ocean[73]. Such science–business engagement will become increasingly important to ensure that companies' sustainability agendas are framed by science rather than the private sector alone[75].

Conclusion

Global economic development has generated prosperity but also inequality, at the expense of the environment[76–78]. Now, within this globalized context, a rising awareness of the finite capacity of the planet creates prospects for change. The global dominance of TNCs is a reality of the Anthropocene, when transformative change is urgently needed. Pioneering companies are learning to persist in their strategies by adapting and innovating in their core businesses, while shaping new strategies and business models that are better fit for the future. Drawing on the six emerging features, and with the intent to help leverage change towards just and sustainable futures, we propose expanding the focus from 'corporate social responsibility' to 'corporate biosphere stewardship'. Stewardship is about caring for, looking after and cultivating a sense of belonging[79,80]. It incorporates both social and environmental dimensions. Corporate Biosphere Stewardship involves shifting excessive, wasteful and imbalanced consumption founded on a fossil-fuel-driven economy into a renewable-energy-based economy of low waste and circularity within a broader value foundation beyond profit alone. Furthermore, corporate biosphere stewardship explicitly acknowledges that people, nations and the global economy are intertwined with the biosphere and a global force in shaping its dynamics[15]. Corporate biosphere stewardship provides a new business logic with the purpose of shepherding and safeguarding the resilience of the biosphere for human well-being. Combined with effective public policies and improved governmental regulations, this new purpose presents unprecedented opportunities and novel pathways for social innovations towards sustainable futures. The jury is out there, whether or not dominant TNCs will become a major force in driving such systemic transformation.

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