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Re-imagining the driver–pressure–state–impact–response framework from an equity and inclusive development perspective

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Abstract

The Driver–Pressure–State–Impact–Response (DPSIR) framework has been used by environmental agencies and others to assess environmental challenges and policy responses. However, in doing so, social justice or equity issues tend to come as an afterthought, while there is evidence that environmental challenges and policy responses are not equity (including gender-) neutral. Hence, this paper addresses the question: why should, and how can, equity issues and environmental justice be incorporated into the DPSIR framework? It presents a structure for including equity within DPSIR and applies it. It reviews the literature to bring together data that demonstrates that there is a clear equity perspective along the entire DPSIR analysis. It concludes that although individual environmental policies may succeed to achieve their specific goal in the short term; if they ignore the equity aspects, the policy strategies as a whole are likely to be environmentally unjust, and lead to exclusive and unsustainable development, which, in turn, could further exacerbate environmental challenges. This highlights the need for an integrated approach in efforts to achieve environmentally sustainable development.

Keywords DPSIR · Biodiversity and Ecosystem Services (BESS) · Equity · Gender · Environmental justice · Inclusive development · Environmental challenges · Inequality

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Introduction

To meet the commitments of Agenda 2030, socio-economic dimensions must be brought into environmental analysis. The core principles of Agenda 2030 require no less: “As we

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embark on this great collective journey, we pledge that no one will be left behind. Recognizing that the dignity of the human person is fundamental, we wish to see the goals and targets met for all nations and peoples and for all segments of society. In addition, we will endeavour to reach the furthest behind first” (UNGA 2015: para 4). This declaration recognizes the interdependence, trade-offs, and synergies between the Sustainable Development Goals (SDGs) and requires “leaving no one behind” and prioritizing the “furthest behind first” (UNGA 2015).

Despite scientific and policy endorsement, “political and scientific ‘bureaucratic silos’ with ‘ethical blindness’ or ‘self-serving’ bias” (EEA 2013:41) promote incremental, symptomatic approaches ignoring equity concerns. The driver–pressure–state–impact–response (DPSIR) framework, used by environmental agencies and the Global Environmental Outlook, has traditionally marginalized equity issues (Carr et al. 2007) except to a limited extent in the impacts and response component. Hence, this paper asks: why should, and how can, equity issues and environmental justice be incorporated into the entire DPSIR framework? It presents an equity sensitive DPSIR framework (see 2), applies it (see 3 and 4), and reflects on the outcomes and implications for inclusive and sustainable development (see 5 and 6). We note that the key message of our paper that the drivers and impacts of environmental degradation are deeply affected by and reinforce growing inequalities in society is a strong message in itself. We choose to specifically connect this to the DPSIR framework because of its structuring influence on environmental analyses by organizations such as the European Environmental Agency, EUROSTAT, and UN Environment. This influential framework requires urgent modification to stay aligned with contemporary international commitments like Agenda 2030.

While most papers on environmental justice use normative arguments; this paper uses the limited available quantified observations from scattered literature to make the empirical and analytical argument that equity is integral to addressing environmental problems sustainably (UNDP–UN Environment 2017:71). Before moving further, we would like to briefly distinguish between equity and equality. Equity is central to enhancing fairness and justice regarding benefits and needs, for example, for women and men, different classes and communities, and between countries. Equality is closely connected to the human rights agenda and refers to equal rights, opportunities, prospects, and power for different groups (Sida 2016). Empirically, this paper focuses on how socio-economic inequalities affect environmental degradation, how different social groups are unequally responsible for driving environmental degradation, and how environmental degradation exposes different social groups unequally to environmental risks. We describe and analyse these inequalities, as they represent and elucidate a range of

equity concerns, acknowledging that addressing them may not be a matter of reducing inequality alone. In order for equity to exist, those who are furthest behind (in terms of class, race, gender, ethnicity, and their multiple intersections) require more than equal treatment. Therefore, while much of this paper focuses on inequality and distributional injustice, we see the growing inequalities as a problem when it affects fairness in terms of exposure to risks and responsibilities; and when the rights of people are affected. We return to this in our conclusion.

Re-shaping the DPSIR framework

Equity, environmental justice and inclusive development

This paper aligns with a broader definition of environmental justice, which goes beyond a focus solely on distributional justice and also includes recognition of diversity, participation in political processes, and procedural justice (Schlossberg 2004). This requires understanding: (a) who manages nature’s contributions (Diaz et al. 2018) in terms of Biodiversity and Ecosystem Services (BESS) (MEA 2005); (b) who has access to and control over these contributions within and between countries; (c) how are the explicit and implicit Rights to use nature’s contributions and Responsibilities (including capabilities to address problems) and Risks (RRR) associated with environmental degradation shared between and within countries, people, and other living creatures; (d) that people have equal moral worth expressed in human rights or rights to development (IPCC 2014a: 319); and (e) that procedural justice includes equal access to information, participation, justice, capacity building, and accountability (Walker 2012). Equity calls for an inclusive development approach which goes beyond pro-poor strategies to address social, ecological, and relational inequalities (Gupta et al. 2015; Pouw and Gupta 2017; Bavinck and Gupta 2017).

Inequity is intersectional, as gender, class, ethnicity, age, race, indigeneity, disability, and spatial aspects combine in complex ways to cause environmental problems and exacerbate vulnerabilities (IPCC 2014b: 49). Inequitable use of resources and production of pollution are reflected in the diverse environmental footprints of nations, sectors, and individuals (WWF 2016). Furthermore, tipping points vary for different socio-ecological entities and systems, not least because stressors can bio-accumulate far from where they were emitted and affect individuals and communities differently (EEA 2013).

As we approach and cross planetary boundaries (Rockström et al. 2009), environmental justice issues become critical, as boundaries also imply more acute and longer

term limits to nature's contributions (Robinson et al. 1973) inevitably calling for either 'life-boat ethics' (Hardin 1974) or a sharing of such scarce resources and sinks or ecospace through reallocating rights, responsibilities, and risks (Gupta 2016). This paper focuses on building the empirical and argumentative case for explicitly integrating these equity concerns in the DPSIR framework.

Why should equity be integrated in the DPSIR framework?

The European Environmental Agency developed the DPSIR framework to ensure science-based environmental policies. DPSIR identifies the relationships between drivers (underlying causes/needs; e.g., economic growth), pressures (human activities resulting from the needs; e.g., use/abuse of resources, emissions, and land-use change), state (effect on the biological, physical, and chemical state, of the environment), impacts (on ecosystem functions and public health), and responses (policies addressing DPSI). Since its initial design, the framework has been considerably elaborated (e.g., Elliott et al. 2017). However, it relies on aggregated data that hide the distributional aspects of DPSIR and do not capture the underlying structural factors causing environmental degradation. Hence, it cannot define and address differentiated problems, instead perpetuating the "reproduction of existing inequalities" (Carr et al. 2007: 543) with knock-on consequences for resource access and allocation and sustainable use. This is reinforced by dominant approaches to knowledge that ignore contextualization (Pascual et al. 2014), exclude other knowledge systems, grey literature, and non-English language literature, and predominantly take a gender-neutral approach.

Therefore, why does equity matter for environmental sustainability? Sceptics argue that the urgency of environmental challenges reduces the time for addressing justice issues ("injustice is preferable to total ruin" (Hardin 1968: 1247)); that equity scholarship being normative is of poor quality, diverting attention from real science and that equity can only be achieved at the cost of the environment (Klinsky et al. 2017).

However, we argue that:

- Equity is substantively integral to sustainable development through strong links between poverty, inequality and the environment (IPCC 2014a: 287; FAO 2014; OECD 2003); that equity is not per definition in conflict with environmental sustainability (Klinsky et al. 2017); and that where there are trade-offs, strong sustainability requires taking both into account;
- Equity considerations are required by moral, policy (e.g., SDG 10), and legal obligations [e.g., see Art 3 of the Climate Convention (UNFCCC 1992)] which require that responsibility is allocated based on causation, capability, and vulnerability;
- A gendered approach could be an important sustainability multiplier (UNEP 2016a, 2016b; World Economic Forum 2016a); For example, empowering women through tenure rights, sexual and reproductive rights, access to education, water, sanitation and health services could have significant impacts on addressing food security, reduce infant mortality and fertility rates (valued at USD 100 billion in demographic dividend (WHO 2016c: 7)), increase income-earning opportunities (valued at a tenfold return on investment through better education and work (WHO 2016c: 7)) and reduce vulnerabilities (UNEP 2016a: 105; 207) as further demonstrated in this paper; and
- Policy effectiveness is threatened when substantive and procedural inclusiveness is violated undermining the legitimacy and compliance-pull of policies (Gupta 2006). Equity can also be important for behavioural change in natural resource use (Kinzig et al. 2013). However, such issues have been neglected in integrated scholarship and related policy processes (UNDP–UN 2017: 65).

Our experience in science-policy communities is that equity sceptics argue that science-based policy requires 'value-free' science and that equity studies are 'value-laden', 'illegible' reflecting different epistemologies and methods (e.g., ethnography and narratives), and are inadequate, as they are argumentative, qualitative, and contextual. However, science-based policy does not imply reliance on 'value-free' natural sciences to the exclusion of social sciences (EEA 2013) for none of the sciences are value-neutral (Lacey 1999; Proctor 1991). Science reflects disciplinary values and the values and gender of the scholars. For example, empirical evidence shows that female economists believe less in the power of the market to solve problems, are less in favour of austerity and more in favour of environmental protection than their male counterparts (May et al. 2018; Griffin 2017), and are, therefore, likely to make different policy recommendations. In fact, the quest for 'value-free' science ignores human–environment interactions as well as the politics inherent in knowledge production and consequently is misleading (McMichael et al. 2003; Oreskes and Conway 2011).

These persistent epistemological challenges also reflect the miniscule scientific budgets for equity issues (e.g., the social sciences received comparatively tiny funding in the US between 1970 and 2015 (National Science Foundation 2017)); and even within the natural sciences, funding focuses on product development in nano-bio and information technology rather than on risks which receives 1% of the funding, biasing investment into potentially risky areas serving

business interests (EEA 2013). Research is biased: e.g., most Intergovernmental Panel on Climate Change (IPCC) authors come from industrialized countries (Schulte-Uebbing et al. 2015) and 87% of global researchers, 92% of the research budget and 94% of scientific publications come from the G20 countries (UNESCO 2015). It is skewed against disadvantaged people as aggregated data hides disaggregated experiences in general (UN 2012: 12) or ignores those left behind, e.g., displaced people (Bennett et al. 2017: 11; IOM 2018). This is counter-productive as effective environmental policy requires knowledge on how to address policy challenges (UN 2012: 9) and environmental policy failure can be related to the inability to account for equity issues (Fleurbaey et al. 2014: 287; Ostrom and Walker 2003; Reed 2011) and barriers to participation (UN 2012). The lack of legitimacy (IPCC 2014a: 327) and limited democratic processes may result in policy processes suffering from capture, clientelism and exclusion (World Bank 2017a, 2017b).

Instead, “Outcomes seen as equitable can lead to more effective cooperation” (IPCC 2014b: 5). Issues of inclusion/exclusion, environmental and social benefits and costs, and RRR to BESS that have been only rhetorically or peripherally addressed, need to be mainstreamed in debates and decision-making processes (UNDP–UN Environment UNEP 2017: 65). Only a comprehensive evaluation of socially disaggregated data and knowledges can lead to balanced science-based policy choices for inclusive development. Equity issues are not an afterthought but need to be integrated in the problem diagnosis from the outset to craft effective responses. While some favour discarding DPSIR (Carr et al. 2007), we suggest integrating equity into the DPSIR framework, as shown in Fig. 1. In the following sections, we apply our approach to the DPSIR framework.



Fig. 1 Integrating equity questions in the DPSIR framework

Applying the framework: drivers and pressures

Drivers and equity

Drivers and pressures of environmental degradation are closely linked and unevenly distributed. They typically include economic growth, technologies, and, controversially, population growth (cf. GEO 2012; see Fig. 2).

Global GDP is estimated at USD 75.4 trillion in 2017. The pursuit of growth drives resource extraction and externalizes environmental pollution and related social costs. Nevertheless, states prioritize it based on the normative assumption that growth enhances ‘average’ welfare. However, this ‘tyranny of averages’ is deceptive, as growth does not imply equitable distribution of welfare or poverty reduction (OECD 2017a, b; Piketty 2014; Ghosh 2011). In fact, resources are increasingly becoming concentrated in fewer hands. In 2017, every day 2 people became billionaires; less than 75 (the number is reducing every year) people (all men) owned as much as the poorest 3.7 billion people combined; the top 1% owned more than the rest of the world and controlled 82% of the growth in wealth; the bottom 3.7 billion experienced no increase in wealth (Oxfam 2018: 8; data from Credit Suisse 2017). Within OECD countries, the top 10% have as much as the bottom half, and the lowest 40% have less than 3% of the wealth (OECD 2017a, b: 13). Within India, resident billionaires have increased from 2 with a 1% share of GDP in 1995 to 46 with a 10% share in 2012 (India Exclusion Report 2016: 5). Furthermore, income inequality and elite capture of resources is highly masculinized from global to local levels, with men dominating the rich, high-consuming urban class, especially at the top of the wealth pyramid. At the top of the income ladder, higher gender inequality is strongly associated with higher income shares in the top 10% income group (Gonzales et al. 2015; UNEP 2016a, 2016b).

Inequality, affluence and related power politics affect growth prospects, as the super rich (both people and corporations) often avoids or evades tax payments amounting to an estimated USD 100–500 Billion annually (Crivelli et al. 2016; Cobham and Janský 2018; OECD 2015). This reduces state revenues for public/merit goods resulting, inter alia, in reduced environmental protection affecting the capital of the poorest and their income-earning opportunities (OECD 2015; OECD 2017a, b; India Exclusion Report 2016). Inequality also affects investment and production patterns: the savings and pension funds of the rich invest heavily in fossil fuel companies which are the world’s largest including Sinopec (China Petroleum & Chemical Corp) and Royal Dutch Shell with revenues of USD 305 Billion

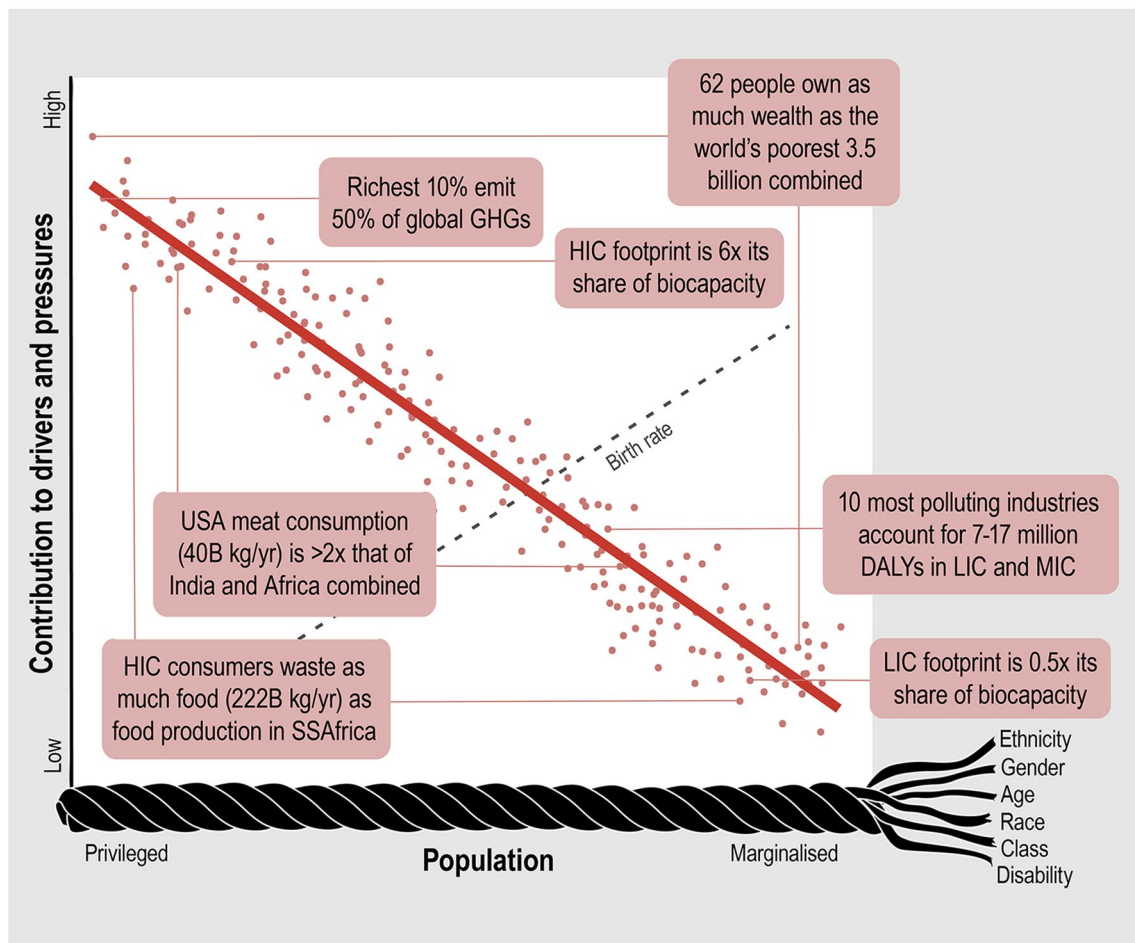


Fig. 2 Drivers and pressures and inequity. Source: building further on IPCC 2014b: Figs. 12.1 and 13.5

and 257 Billion, respectively¹; these companies do not wish to be left with stranded assets and lobby intensively to preempt decarbonisation policy (Klein 2014). Crony capitalism leads to deregulation, reduced taxation, and/or big subsidies for large industries, because they often default on payment (India Exclusion Report 2016: 11). Capital and trade lead to re-distribution of the per capita benefits of land use from developing to industrialized countries. This results in, for example, large-scale land (and water) grabbing (47 Mha) (Rulli et al. 2013).

Inequality affects consumption patterns. For example, the per capita ecological footprints of high-income countries (HICs) are 6 times larger than their per capita share of global biocapacity (1.7 gha), while those of low-income countries (LICs) are less than half their per capita biocapacity (WWF 2016: 78). Between 1961 and 2012, the average per capita footprint in HICs increased from 5 gha to 6.2 gha, in middle-income countries (MICs) from 1.4 to 2.3 gha,

and in LICs remained flat at 1 gha (WWF 2016: 80). HICs have a higher per capita urban footprint (180.5 sq m) than LICs (43.7 sq.m) (Pesaresi et al. 2016). “Gendered consumer demands, transport use patterns and car driving trends show a gendered ecological footprint and contributions to climate change” (Angeles 2017: 103; see also: UNEP 2016a, 2016b; Cohen 2015). Moreover, more than 56% of the land footprint associated with EU consumption was from outside the EU (EEA 2015: Figs. 2, 3). This underscores the extent to which inequitable production and consumption patterns produce environmental degradation elsewhere. Thus, “Northern historical development and present production and consumption levels are reliant upon a socio-ecological ‘subsidy’ imposed on Southern countries” through a disproportionate use of global commons and sinks (Rice 2009: 233–235).

A second driver, technology, and innovation has accelerated the pace and extent of access to water, food, shelter, and varied goods and services, including in areas where they have been absent or in limited supply. Technology can decarbonize, dematerialize, and detoxify production patterns and reduce the demand for, and enhance the quality of, BESS

¹ <https://www.statista.com/statistics/272711/top-global-oil-and-gas-companies-based-on-net-income/>.



Fig. 3 Markets selling illegal wildlife products in Laos. Photo by Joyeeta Gupta

if regulation requires it, investment patterns promote it, and countries and people can afford it—all of which can be affected by the above-mentioned inequalities.

However, technology developers have also externalized environmental justice issues through: continuing in a path-dependent manner as a way to avoid being left with stranded assets—oil/gas (Economist Intelligence Unit, 2015); enabling large-scale extraction and pollution; concentrating control over land, water, minerals, data (e.g., through information technologies), and seeds (e.g., 4 companies controlled 56% of the seeds market via bio-technology in 2008 (Howard 2009:1270)); and developing risky technologies for profits while the risks are under-studied and externalized (EEA 2013).

Population dynamics and growth are often posited as drivers of environmental degradation, which is based on controversial and contested arguments. Neo-Malthusians argue that population growth from 7.6 billion people in 2017 to 11.2 billion in 2100 (UNDESA 2017:1) is outstripping the Earth's carrying capacity, thus implicitly blaming the poor (see, e.g., Hardin 1974) and women (Bandarage 1997; Hartmann 2014) for global environmental crises. Considerable evidence shows that population growth, if a “driver” at all, is a derivative one: gender inequalities and lack of access to resources, education and health services, child marriages [e.g., every 2 seconds a girl is married off, (UNDP 2016: 5)], and restricted sexual and reproductive rights contribute to high fertility rates. Countries with high infant mortality have high fertility rates and a fall in child mortality precedes the fall in fertility rates (Bavel 2013; UNDESA 2017: 5/12). Education reduces child mortality and increases birth control (Smith-Greenaway 2013; Cohen 2008) especially when there is access to contraceptives (UNFPA 2011) and women are

empowered (Blanc 2001; Do and Kurimoto 2012) making women's empowerment also a sustainability multiplier.

Pressures and equity

The pressures on our ecosystems include climate change, food production, chemicals, mining, energy production, waste, trade, and transport (UNEP 2013), each having an equity dimension. Climate change is caused by greenhouse gas (GHG) emissions. The richest 10% emit 66% of the GHGs, while the poorest 50% emit 15% (Hubacek et al. 2017; see also Oxfam 2015: 1); globally, 100 corporations emit 71% of global CO₂ emissions (Griffin 2017). The per capita carbon footprint of the lowest income category is 1.6 t per day and 17.9 t per day for the high-income category (Hubacek et al. 2017).

Similarly, food production is disproportionately geared towards serving the rich (cf. Ritchie and Roser 2017) combined with a poor distribution system, leading to 800 million hungry people and 2 billion with micronutrient deficiencies (FAO 2016: 8), while 1.9 billion eat too much (WHO 2018). For example, in 2017, USA meat consumption was 40 Billion kg, which is more than two times the total meat consumption of India and Africa combined (OECD 2018). Livestock production, including feed crops, uses 70% of agricultural land (FAO 2006:xxi), drives land-use change causing deforestation (Machovina et al. 2015), while emitting 18% of GHGs (FAO 2006/16:xxii), using 8% of global human water use, being the largest sectoral source of pollutants (animal wastes, hormones and antibiotics, chemicals, fertilizers and sediments causing eutrophication, coral reef damage, etc.), and the leading sector in biodiversity damage (FAO 2006: xxiii/2016). In addition, meat consumption and production is highly masculinized and skewed towards upper income classes.

Rising food production by 60–100% by 2050, if addressed by intensive agriculture, will negatively affect BESS (Tilman et al. 2011: 20260) which will damage the assets of the local and indigenous peoples and lead to loss of income (damage and loss). Global fish production was 174 Mmt in 2017.² While fish consumption is not as strongly correlated to income per capita (Ritchie and Roser 2017), per capita *growth* in fish consumption is higher in industrialized (from 5.2 to 18.8 kg over 1961–2013) than in low-income food-deficit countries (from 3.5 to 7.6 kg) (FAO 2016: 2). Furthermore, inequality affects the amount and reasons for food wastage: More than 1/3rd of food produced (1.3 Bt, UNEP 2015: 114) is wasted costing USD 680 billion and

² <https://www.statista.com/statistics/264577/total-world-fish-production-since-2002/>.

USD 310 billion in industrialized and developing countries, respectively. Northern consumers waste more (95–115 kg annually) than Southern ones (6–11 kg annually)³, where waste is often due to the lack of refrigeration and transportation facilities.

The large-scale extraction, distribution, production, and disposal of minerals (e.g., oil, gas, and gold) and chemicals (e.g., fertilizers, pesticides, medicines, microplastics, and nanoparticles) causes local-to-global pollution. Such processes are often geared towards meeting the consumption needs elsewhere. For example, in 2005, 57.7% of global land-use changes caused by nickel mining for use elsewhere occurred in five countries (Nakajima et al. 2017: 730). Extraction also leads to (ground)water pollution, earthquake hazards, subsidence and sinkholes as well as mining wastes approaching 100 Bt annually⁴ on land and offshore.

Plastic packaging exceeds 320 Mt annually of which 40% is used for single-use packaging (Wright and Kelly 2017: 6634) mostly in industrialized countries; but 95% of ocean plastic comes via 10 rivers of which 8 are in Asia and 2 in Africa because of poor disposal practices (Schmidt et al. 2017: 12252) and the export of plastic wastes to these countries. Waste nearly doubled between 1970 and 2000 and continues to grow (UNEP 2017: 29) with cities generating 7–10 Bt annually. There are more than 2.5 million contaminated sites in Europe. Industrial and hazardous waste generation is shifting from industrialized to emerging economies, which are often poorly prepared to safely manage these waste streams.

While trade and transport enhance growth, they also accelerate degradation. Wood trade of USD 226 billion (2015) drives deforestation (FAO 2015b). Transport uses resources and water, is a key emitter of GHGs and air pollutants, and releases invasive species in ecosystems (Hulme et al. 2008; 403). Yet, 90/193 countries do not have vehicle emission standards and existing standards are often violated in those that do have them. 80% of global diesel vehicles have higher emissions than certification limits (Anenberg et al. 2017). This is further exacerbated by environmental crime globally (USD 91–259 B) which includes illegal wildlife trade (USD 7–23 B; see Fig. 3), forestry (USD 51–152 B), fisheries (USD 11–24 B), and mining (USD 12–48 B) making it the fourth-largest crime (Nellemann et al. 2016:7: Stimson Centre 2016) benefitting the criminal industry and buyers often at the cost of the poor.

Thus, drivers and pressures of environmental degradation result from and exacerbate existing inequalities.

Equity-blind and equity-neutral assessments fail to address these underlying causes of environmental degradation.

State and impact

Introduction

This section examines the equity dimension of ‘state’ and ‘impact’ in the DPSIR formulation: Who manages and controls existing ecosystems; how is exposure to environmental benefits and risks distributed, and how are impacts distributed over different social groups given differential adaptive capacities?

Atmosphere and equity

Atmospheric pollutants include indoor household pollution at local level in developing countries, local-to-transboundary air pollution, and local-to-global climate change.

Household air pollution from cooking with unsafe fuels and stoves threatens the health of 2.8 billion people (especially women who cook) and children in rural and peri-urban areas in developing countries (Chafe et al. 2014: 1314); as income increases, household air pollution decreases (UNDP 2011a). Ground-level ozone can reduce global crop yields by up to 50 Mt/year increasing risks to small farmers.⁵ Over half the world’s population lives in urban areas but only 12% of cities meet WHO air quality standards⁶; 98% of cities in LICs and MICs which collect data exceed WHO Guidelines for PM 2.5 and PM 10, as compared to 56% for cities in HICs exposing their citizens to health risks (WHO 2016a, b). Increased PM 2.5 (particulate matter with a diameter < 2.5 micrometers) can enter the lungs and heart (World Economic Forum 2016b). Such air pollutants and climate change-related temperature changes increase the vulnerability of specific people (older people, children, chronically ill people, and socially isolated poor people) and occupations (outdoor workers) (Sarofim et al. 2016 discussing the USA). Vulnerability to climate change is also differentiated: the highest emitters are often the least vulnerable to climate change (20 of 36 most emitting countries), while countries with low and moderate emissions are highly vulnerable (11 of 17 low/moderate emitters); this inequality is projected to get worse by 2030 (Althor et al. 2016). Tropical areas and Small Island Developing States and agricultural populations in Asia and Africa will be worst affected (UNDESA

³ <http://www.fao.org/save-food/resources/keyfindings/en/>.

⁴ http://wedocs.unep.org/bitstream/handle/20.500.11822/21800/UNEA_towardspollution_long%20version_Web.pdf?sequence=1&isAllowed=y.

⁵ UN Environment, Dimension of Pollution—Air: <http://web.unep.org/environmentassembly/air>.

⁶ UN Environment, Dimension of Pollution—Air: <http://web.unep.org/environmentassembly/air>.

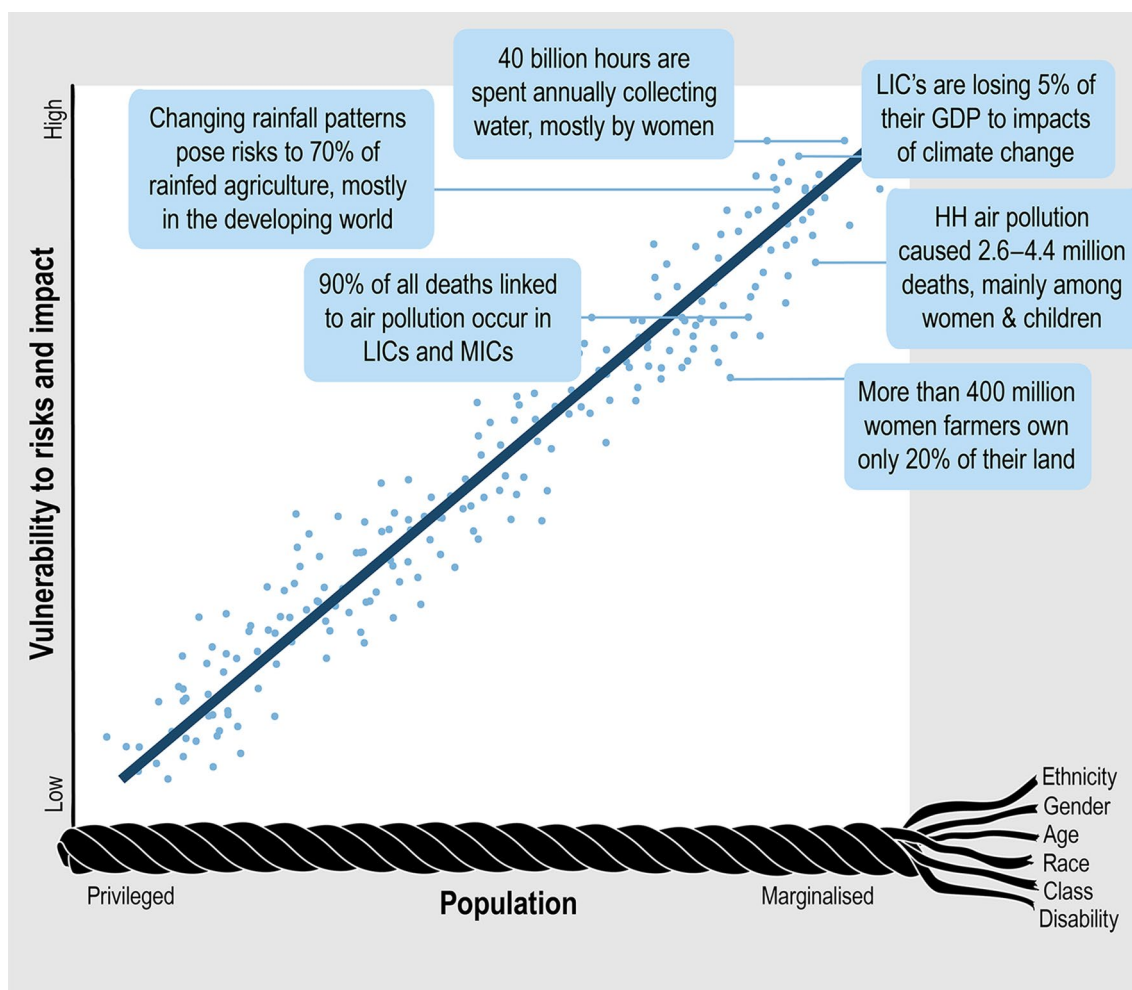


Fig. 4 State, impact, and inequity. Source: building further on IPCC 2014b: Figs. 12.1 and 13.5. NB. The exposure to state and the actual impacts are higher in existential terms and in terms of the percent-

age of their incomes for the marginalized. If one were to examine the exposure to risk and actual impacts in monetary terms, it is possible that the rich suffer more.

2016: vi; Boko et al. 2007: 189). Climate change exposes 26% of the world population below 15 to long-term risks (UNDESA 2017:1). Adaptation and disaster relief costs will keep increasing (Klein et al. 2014).

In terms of actual inequality of impact, air pollution is the fourth-largest threat to human health (World Economic Forum 2016b) leading to 6.6 million deaths in 2012 (11.6% of mortality) (WHO 2016b) and 1 in 10 deaths in 2013; this costs the global economy about USD 225 billion in lost labour income (World Economic Forum 2016b). More than 90% of pollution-related deaths are linked to air pollution in LICs and MICs (World Economic Forum 2016b; Landrigan et al. 2017:462). Household air pollution caused between 2.9 and 4.3 million deaths, mainly in women and children in 2012 (Landrigan et al. 2017:471) causing losses estimated at 0.68% of GDP in LICs (Landrigan et al. 2017:484). About 82% of deaths due to air pollution in HICs affect people aged > 64, with women often worse affected (Health Effects Institute

2017: 8). Millions more suffer from cancer, pneumonia, heart and lung disease, blindness, and burns, while smoke from cooking fires is associated with cataracts which causes blindness. Welfare losses from pollution are estimated at USD 4.6 trillion annually (Landrigan et al. 2017: 462). Approximately 6457 extreme weather events have led to 600,000 deaths and affected 4.2 billion people (1995–2015) with LICs losing 5% of their GDP on average (UNDESA 2016: vi; Centre for Research on the Epidemiology of Disasters and United Nations Office for Disaster Risk Reduction 2015) (see Fig. 4).

Land and equity

While land supports BESS, much of which is managed daily by local communities and indigenous people, it has been heavily degraded by the drivers and pressures.

In terms of ‘state’, globally, about 24% of land was degraded between 1981 and 2003 affecting the livelihoods

of 1.5 billion people (Bai et al. 2008:i–ii) increasing to 29% by 2014 affecting 1.3–3.2 billion people (UNCCD 2017: 8). 12 M hectares of forest land have been degraded annually (FAO 2015a) affecting directly dependent local and indigenous peoples, not least because land species populations of flora and fauna have declined by 38% (1970–2012) (WWF 2016:22). While pollination for commercial food production (excluding pollination for subsistence agriculture and wild plants) is valued at USD 351 B/year (Lautenbach et al. 2012; IPBES 2016: xi), pollinators are declining in numbers largely from pesticide use and habitat destruction.

About 2 billion people in poor countries lack access to solid waste collection, and 3 billion to controlled waste collection disposal facilities (d-Waste 2014) exposing them to health risks. This is exacerbated by growing illegal waste dumping, since dumpsites are home to 15 million waste pickers (WIEGO 2013: 30).

In terms of who uses and who owns the land, 2.5 billion people depend directly on land, but only own 10% of that (Oxfam 2016a, b). More than 400 million women farmers own only 20% of the land they work on (FAO 2011: 5,23), and in 90 countries, customs inhibit women from owning land. 1 billion people in mega cities do not have property rights (Habitat for Humanity 2016: 2), while 881 million people lived in urban slums in 2014 and this number is fast growing (UN Habitat 2016: 51). Family farms operate about 75% of the world's agricultural land, with farms decreasing in size in LICs (Lowder 2016:16). The global annual cost of soil salinization could be USD 27.3 billion in crop losses (Qadir et al. 2014: 288) affecting the poor farmers the most. In 2017, about 20 million people faced famine in 4 African countries including 1.4 million children facing imminent risk of death (Grebmer et al. 2017).

In terms of actual impact, about 54% of the global burden of disease counted in Disability Adjusted Life Years (DALYs) from chemical exposure on land is borne by children under 15 (Prüss-Ustün et al. 2011: 7). Women and children have a higher risk from chemical contamination from endocrine disruptors and pesticides. Land grabbing (276 new deals between 2012 and 2016) has led to income losses for 12 million people—mostly poor people (Nolte et al. 2016:1), dispossession of local farmers [e.g., the African continent accounts for 42% of all the land grabbing deals (Nolte et al. 2016: vi–vii)], and more than 2000 recorded cases of socio-environmental conflicts (Temper et al. 2015: 269).

Freshwater and equity

Freshwater is inequitably accessed and used by agriculture, industry, tourism, and households and is key to the survival of land and water-based ecosystems. It is increasingly being extracted beyond recharge levels, diverted from one area to another, and polluted.

In terms of state, water's contribution to nature is considerable: for example, wetland BESS are valued at USD 300 to USD 887,828 ha/year-1 (De Groot et al. 2012: 55). However, not only are wetlands being drained, the *per capita* availability of fresh water is decreasing. About 2/3rds of people around the world face severe water scarcity for at least 1 month/year (UNDESA 2016: 31). Between 1992 and 2014, the number of countries with water scarcity increased from 30 to 50 (WWF 2016: 54). More than 700 million people in 43 countries face water scarcity (Hameeteman 2013:3). This will be exacerbated by climate change as changing rainfall patterns poses risks to 70% of agriculture (IPCC 2014a, 2014b) mostly in the developing world. West Asia may receive 20% less rainfall in the next 50 years (Salam et al. 2017: 175). In terms of access to potable water, rural people are worst affected: in 2015, 844 million people lacked drinking water services (WHO 2017:3). About 40 billion hours are spent annually collecting water, mostly by women (WHO 2016a, 2016b, 2016c: 28). Moreover, the heavily polluted freshwater from different pressures including newer threats such as antibiotic pollution and fracking causes disproportionate damage and loss to the poor. The new chemicals being used are increasingly difficult to remove affecting BESS. Water scarcity, climate change, and pollution may displace 100 s of millions of people by 2030. Small islanders (e.g., in Kiribati and Tuvalu) may have to migrate as their land submerges or drinking water runs out (Nurse et al. 2014).

In terms of impact, water-related mortality and sickness costs USD 122.8 billion and USD 16.5 billion, respectively, in lost earnings, while health care costs USD 56.6 billion annually (Lixil Water Aid and Oxford Economics 2016: 4). In 2015, poor sanitation cost USD 222.9 billion affecting mostly women; about 0.9% of GDP in some affected countries (Lixil Water Aid and Oxford Economics 2016: 3). Approximately 40% of the world's wetlands were lost between 1997 and 2011 with an annual economic cost of USD 2.7 trillion in terms of wetland, swamp, and floodplain losses to local people (Ramsar 2015).

Oceans and equity

The current state of the oceans reveals dying coral reefs (NOAA 2017), damaged mangroves, acidification, declining fish resources, exposure to coastal disasters, offshore oil pollution, hydrocarbon accidents, growing microplastic debris, and salt water intrusion.

Marine BESS are estimated at USD 2.3 trillion annually for tourism-related activities (Inniss et al. 2016)⁷ and USD

⁷ http://wwf.panda.org/what_we_do/how_we_work/our_global_goals/oceans/solutions/recognising_the_value_of_marine_ecosystem_services/.

252 billion for fishing-based activities employing 58–120 million people (Inniss et al. 2016, 9/11/12). It provides livelihoods to over 500 million people (Fisher et al. 2017) and 275 million people in 79 countries depend on reef fisheries for animal protein (Wilkinson et al. 2016:1). 75% of countries where fish provides an important source of animal protein are food deficient (Béné et al. 2015: 261), and hence, 11% of the current global population are at risk, especially the poor, of becoming micronutrient deficient if fish-catch declines continue (Golden et al. 2016: 317). Such decline is likely as commercial fish stocks have declined drastically in the North Atlantic (UNEP 2008; IUCN 2012) leading to increased fishing in foreign waters; 32% of all fish stocks are overfished, and another 60% of stocks are exploited at the maximum sustainable level (FAO 2018). Furthermore, exploitation rates are uneven. 13 seafood companies control 19–40% of the world's important fish stocks (Österblom et al. 2015: 6) and only 4% of the fishers, operating large-scale vessels, catch 76% of the fish (Pauly and Zeller 2016: 176) while receiving 84% of the fish related subsidies (Schuhbauer et al. 2017: 114). South-Asian and Pacific countries are highly dependent on fisheries that are increasingly vulnerable to climate impacts (Barange et al. 2014: 212). Around 40% of the world population live in coastal areas, probably doubling by 2050, thus exposing more people to sea level rise, salt water intrusion affecting drinking water supplies and infant mortality (Dasgupta et al. 2016: 15) and extreme weather events (UNEP 2007: 170). Small island states could be badly affected: Pacific island states could lose up to 6.6% of their GDP to natural hazards (UNEP 2016b: 89). Arctic indigenous peoples are disproportionately exposed to the impacts of climate change and bio-accumulation in high trophic-level marine species (Borgå et al. 2004: 2368).

Although equity data on actual impacts are scarce, coastal disasters like Hurricane Katrina cost more than USD 200 billion, and left 1200 dead and 1 million temporarily displaced people in the US (Dolfman et al. 2007:3); many long-term affected were African-American (Elliott and Paes 2006, Morello-Frosch et al. 2009 and Fussell et al. 2010). Such disasters affect women disproportionately with thrice as many Indonesian men as women surviving the Indian Ocean Tsunami in affected regions (Rofi et al. 2006: 343); 61% of those who died in the Myanmar cyclone in 1998; and 65% of those who died in Sri Lanka in the 2004 tsunami were women, though less women than men died in relation to such disasters in the US between 2004 to 2013 (UNEP 2016a, 2016b: 208). There is also evidence of gender-based violence after catastrophes such as in the US after Katrina (Jenkins and Phillips 2008) and Ethiopia and Bangladesh after incidents of drought and flood; Goulds 2011). Such violence is triggered by loss and grief, greater tension and disrupted safety nets (IPCC 2014b). Offshore hydrocarbon accidents (2003–2010) have a fatality rate which is seven

times higher than the rate for workers in the US (Harris et al. 2016: 18) affecting the workers as opposed to the consumers.

Biodiversity and equity

The above-mentioned drivers and pressures have led to the sixth mass extinction event (Barnosky et al. 2011). The Global Living Planet Index declined by 58% during 1970–2012 (WWF 2016: 15) and 58.4% of land is compromised in terms of biodiversity (Newbold et al. 2016). 41% of amphibian species are threatened with extinction (IUCN 2012) and flying insect biomass has declined by 75% in 27 years in protected areas. Freshwater species populations have declined by 81% (1970–2012) (WWF 2016: 30). In 2017, the longest, most damaging Third Global Coral Bleaching Event ended with major impacts for the Great Barrier Reef, Kiribati, and Jarvis Island (NOAA 2017).

As biodiversity declines, the vulnerability of those directly dependent in terms of access to water and food, reliance on pollinators, employment, as well as storm protection, increases. For example, coral reefs provide food, storm protection, and jobs for the coastal poor as well as recreation and other income sources for more than 500 million people worldwide, yet 70% of coral reefs are threatened or destroyed by development projects, pollution, and ocean warming. Mangroves, that have provided livelihoods and protection from disasters, are threatened through 'development' and sea level rise. Around 35% of mangroves have disappeared in the last 20 years and more than one in six mangrove species is endangered (Webber et al. 2016). Moreover, as indigenous peoples live on and use up to 22% of global land, home to 80% of global biodiversity (World Bank 2008: 5), they play a key role in conserving biodiversity. With increasing land grabbing, their ability to maintain biodiversity decreases.

In terms of actual impacts, the loss of species affects agricultural revenue, food security, and tourism revenue. If pollination for commercial food production is valued at USD 351 B/year (Lautenbach et al. 2012; IPBES 2016: xi), this can indicate what the large-scale death of pollinators could mean to subsistence farmers. Losses from invasive species in US, UK, Australia, South Africa, India, and Brazil are estimated at more than USD 300 B annually; the EU's losses are estimated at Euro 12.5 B/year (Kettunen et al. 2008). The annual burden from invasive species in the US is USD 120 B; curiously, the loss is borne by the public, while profits of the activities which lead to invasive species go to the private sector (Suckling 2017).

Implications for response

The DPSIR framework requires the responses to be directed at addressing the DPSI. However, if the analysis of DPSI is incomplete, the responses will also be inappropriate. We have

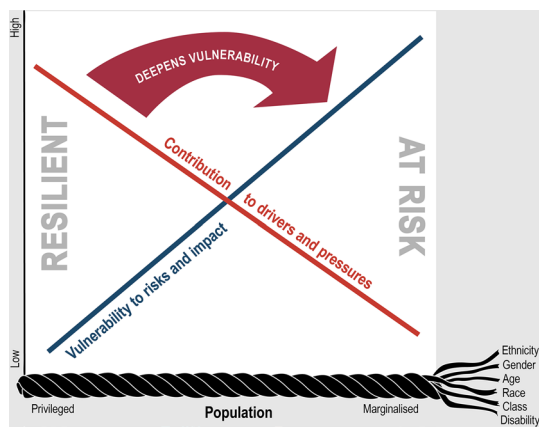


Fig. 5 Contribution to drivers and pressures and vulnerability to risks (state) and impacts of privileged and marginalized people. Source: building further on IPCC 2014b: Figs. 12.1 and 13.5. NB. The exposure to state and the actual impacts are higher in existential terms and in terms of the percentage of their incomes for the marginalized. If one were to examine the exposure to risk and actual impacts in monetary terms, it is possible that the rich suffer more

shown that the drivers and pressures result from and exacerbate inequalities, that there are differentials in dependency on and protection of the environment, and that state (exposure) and impacts are also differentiated. In particular, there is evidence that BESS are looked after by indigenous and local people and that it is the source of income and capital for the poorest, as 70% of the world’s poor directly depends on natural resources (Green Economy Coalition 2012: 4) and depleting these resources increases their vulnerability. 45% of women depend directly on fisheries, forests, hunting, and agriculture for their livelihoods (FAO 2011). 1–1.5 billion people derive direct and indirect benefits from forests (Agrawal et al. 2013: 4). For example, 480 million poor Indians directly depend on 47% of the BESS and rural Brazilians are 90% dependent on BESS for maintaining their livelihoods. These services are the ‘Gross Domestic Product (GDP) of the rural poor’ (TEEB 2010: 14). With declining BESS, there is not only damage to commercial ventures (which tend to be calculated), but very high damage to the “wealth” and health of the poor as well as loss of income generating opportunities (see Fig. 5).

If we accept that meat demand is a big and gendered problem, then the environmentally sound argument that ‘we’ must reduce meat consumption will not be effective without policies addressing the gender dynamic (UNEP 2016a, 2016b). If we accept the gendered nature of food production, then by closing the gender gap in Malawi, its agricultural productivity could be increased by 28% amounting to a 7.3% increase in crop production, a USD 90 M increase in agricultural GDP, a USD 100 M increase in total GDP, and 238,000 people being lifted out of poverty (UNDP–UN Environment PEI 2017: 23). Giving women farmers worldwide more resources could reduce the number of hungry

people by 100–150 million⁸ and reduce child mortality. If indigenous and local communities had tenure security, they could potentially protect these lands through traditional land management and carbon sequestration practices (cf. Reed 2011). If we accept that GHG mitigation and adaptation are strongly linked to inequality (IPCC 2014a, b: 5), then:

“Given other policy goals, especially poverty alleviation, a re-distribution of carbon shares from the global elites to the global poor seems to be desirable; ... Given the huge level of carbon inequality, critical discussion of undifferentiated income growth and current carbon-intensive lifestyles and consumption patterns need to enter the climate discourse to a larger extent” (Hubacek et al. 2017: page 4 online version).

Accordingly, a successful environmental policy will have to revisit the concept and content of growth including the role of power, technology and the state to devise fair rules to govern the sharing of the global commons sustainably. We may have to move towards regenerative growth (Raworth 2017), making states responsible for global goods and promoting constitutionalism to control power (Gupta 2016). Avoiding the irreversible consequences of bio-, nano-, and information technologies requires application of the precautionary principle as by the time the evidence is available we may be locked into these technologies (EEA 2013).

Analysis

The foregoing DPSIR-equity analysis goes beyond normative rhetoric and data mining, providing a partial picture of emerging environmental justice knowledge. This collection of diverse data and trends provides prima face evidence to draw some equity-related hypotheses or narratives.

First, in assessing whether drivers result from, mitigate or exacerbate existing inequalities, we can hypothesize that growth, technologies, and population dynamics result from, but also, exacerbate existing inequalities. While growth and technologies may enhance average welfare and mitigate existing inequalities, in the absence of dedicated environmental justice policies, it is more likely to exacerbate inequalities through labour substitution; accelerate resource extraction, production processes, trade, consumption and waste trends; externalize pollution risks and impacts; and increase capital and alternative currency transfer worldwide both legally and illegally to also enable tax evasion and avoidance, while ignoring the role and impacts on the poor.

⁸ http://documents.wfp.org/stellent/groups/public/documents/communications/wfp232415.pdf?_ga=2.88478994.86769278.1509609325-981731691.1475680098.

This can be done with impunity, since multi-dimensional inequality supports inequitable science budgets which lay the science and policy foundations for unsustainable and risky growth, investment, production, distribution and consumption patterns, and inequitable distribution of GHG emissions and risks, leading to unsustainable lifestyles for some and unreachable aspirations for others. This is further aggravated by the tipping points of BESS which raises the issue of limits to our ecospace.

Second, in analysing pressures and who uses and pollutes resources and sinks beyond their carrying capacity, we hypothesize that income is a key determinant of demand for provisioning services (e.g., food, water, oil, sand, wildlife, and land) and, where relevant, their production, trade, transport, and consumption—with as a general principle the richer the economy and the person, the greater the direct consumption or investment (through savings and/or pension funds) with greater impacts outside their national jurisdiction. When it comes to pollution, richer countries pollute more into the global commons (e.g., GHGs—where the impacts are exported); poorer countries tend to have more indoor, local and regional pollution (e.g., air/water/solid waste—where the impacts are also locally suffered although possibly more by the poorer people, by women because of their greater sensitivity to some chemicals and children because of their lower tolerance level (UNDP 2011a, b)). Moreover, much of the air and water pollution generated by local industries in poor regions is a function of demand from richer consumers elsewhere.

Third, not only is the state of the environment differentially impacted both directly and through teleconnections, there is also differentiation in who looks after the environment (e.g., the indigenous and local communities; the landless labourers; and especially local women), who gains from the environment (e.g., who profits from access and benefit sharing) and who is exposed to environmental risks in terms of the reduced provisioning, supporting, regulating, and cultural services. Multi-dimensional inequality leads to reduced access to BESS (e.g., land, water, natural resources but also flood control) and greater exposure to climate disasters; this exacerbates poverty, reduces adaptive capacity, and endangers human health. If we exceed tipping points, the GDP of the rural poor is destroyed first. Using resources for survival ('survival emissions' Agarwal and Narain 1991) also has an environmental cost but this is relatively limited.

Fourth, in examining the distribution of impacts, i.e., who is able to adapt and who pays for residual damages, we see that the impacts of environmental damage are inequitably distributed in social, spatial, and temporal terms. Multi-dimensional inequality has led to death and disease for marginalized people (including women and children); forced migration into marginal habitats (e.g., migration to remote and peripheral areas, coastal lands, higher up the

mountains, and peri-urban areas); and forced the poor into marginal and unhealthy labour situations (e.g., garbage separation, ship-breaking industry with impacts on coastal areas), making inappropriate choices (e.g., collecting wood for charcoal; or dangerous and cheap fishing technologies). This may also exacerbate human vulnerability and environmental health and possibly increase conflict and displacement (drought has arguably contributed to the displacement of 22 million Syrians; (Kelley et al. 2015)). Globally, the 10 most polluting industries account for 7–17 million DALYs in LICs and MICs (Pure Earth and Green Cross Switzerland 2016: 6). The benefits and risks of exposure to and impacts of environmental change are not equitably shared now and in relation to future generations (World Bank 2017a, 2017b: 81; Landrigan et al. 2017; Kasperson and Kasperson 2001). The costs of inaction on equity run into the billions and are externalized to the weakest and most vulnerable while the profits from not acting go to short- and medium-term investors: the Economist Intelligence Unit (2015:2) calculates that the cost of inaction on climate change could on average reduce the world's stock of manageable assets (USD143 trillion) by USD 4.2 trillion (discounted and in present value) in 2100 which equals the value of oil-and-gas companies, but this rises rapidly when the average temperature rises to 5°–6°. Adaptation and residual costs are generally borne by local people.

In relation to *responses*, we hypothesize that policies are never neutral—they redistribute access and re-allocate RRRs (both intended and unintended); marginalized people are vulnerable to both adaptation and mitigation responses (IPCC 2014a, 2014b: 50). Furthermore, if policies address symptoms, or inappropriately defined underlying drivers of environmental problems, they will not be able to sustainably address the underlying drivers of environmental problems. Where economic growth is directly linked to the exploitation of minerals, land, water, and related products and services, growth will lead to competition over this scarce ecospace. Such competition could lead to neo-liberal privatization options to enclose the commons and hegemonic approaches to protect the national interest (e.g., 'America first') (Gupta 2015) probably benefiting those with capital and technology over those living in disadvantaged positions. However, there is potential for redefining growth through the Sustainable Development Goals and dedicated policies. For example, between 50 and 90% of global GHG emission reductions required can have net benefits (Stern and Calderon 2014: 15), green growth strategies could secure co-benefits, and doubling the share of renewable energy could lead to millions of jobs, but such co-benefits will not be automatically achieved (Mayrhofer and Gupta 2016a, b), nor will it automatically ensure the 'furthest behind first'. Environmental justice including gender-based approaches is needed in these transformations (UNDP 2012; Angeles 2017).

Where policies address underlying drivers and aim for triple-loop learning and transformative change to achieve the SDGs, they will have to be led by both precautionary and equity principles. The first pre-empts a lock-in into unsustainable patterns and requires more research into risks, the second ensures that the other SDGs on reducing inequality, empowering women and helping the ‘furthest behind first’ do not imply a doubling or tripling of environmental pollution but a re-distribution of ecospace. Both are challenged by short-term political and business horizons, technology monopolies, conservative science, and elite capture of the global political process (EEA 2015; Klein 2014; UNDP 2016: 79) with the intent to keep the status quo. In the long term if inequitable policies and vulnerability are locked into a vicious cycle, this will further exacerbate population dynamics (growth and migration), lead to conflict, and compromise on environmental effectiveness. Furthermore, the more inclusive the democratic process the better the environmental performance of policies (Environmental performance indicators 2014).

Conclusion

In the Agenda 2030 Age, humans must share nature’s contribution with each other and with nature. Agenda 2030 requires minimizing trade-offs, pre-empting conflicts, maximizing synergies, and promoting prosperity while keeping environmental justice as the guiding principle. We argue that only a comprehensive evaluation of disaggregated data and knowledges can lead to effective science-based environmental policy choices that the DPSIR framework can be enriched by integrating equity issues leading to triple-loop learning. Despite the low availability of global-level differentiated data and analysis, there are sufficient data that demonstrate *prima facie* that spatial, income, racial, and other inequities and gender inequality characterizes or shapes the drivers (e.g., growth/technology and population dynamics) and pressures (e.g., GHG emissions, resource demand, and pollution) of environmental degradation.

There is evidence that people are differentially engaged in managing BESS and gain differentially from BESS with women having significant agency and that the current state of the environment affects different communities differently in terms of damage to ecosystem wealth and human health and loss of income. Those most exposed are those who directly rely on natural capital for their livelihoods—the ‘GDP’ of the ‘poor’ (e.g., rainfall, fish, and coral reefs) and those who are disproportionately impacted by extreme weather events (e.g., the elderly, women and children, those without safe housing, those in marginal areas and low-lying coastal regions).

We argue that if policies and actions are based on an incomplete analysis of the problem, these will be at best

incremental responses to addressing symptoms (see Carr et al. 2007). They will not address the underlying structural causes (i.e., the current definition of growth, what causes population growth, inequality), nor will they assess the role of equitable policies in effective problem solving.

Addressing the climate change problem will only be possible through the re-distribution of emission rights (Hubacek et al. 2017); limited resources and sinks will inevitably call for a re-distribution of ecospace between countries (Gupta 2016).

Finally, there is urgent need for disaggregated data, bottom–up research, using traditional knowledge and equity approaches based on multiple epistemologies to draw refined conclusions on equity and the environment for use in horizontally and vertically integrated policy that address environmental degradation and inequality. Hence, science needs to undertake integrated long term rather than fragmented and selective research to support economic gain. The latter “lead to inferior solutions and provides increased opportunities for those with vested interests to manufacture doubt. The assertion that there is no evidence of harm is then often assumed to be evidence of no harm, even though the relevant research is missing” (EEA 2013: 40). A failure to emphasize disaggregated knowledge institutionalizes inequity. Understanding the role of inequality in exacerbating inequity and vice versa is thus critical. Thus, “transformative pathways... require transformative knowledge.. that is co-created with those who are experiencing inequalities” (UNESCO 2016; 279), land the “combining of ‘thin’ (readily measurable) information and ‘thick’ (context-specific) knowledge” (UNESCO 2016; 243) as the only way to address the “abundance of prejudice and a paucity of fact” (Piketty 2014: 2).

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