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Incorporating Environmental and Natural Resources within Analyses of Multidimensional Poverty

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Abstract

How can multidimensional poverty measures – that currently encompass social and economic dimensions – be extended to include environmental deprivations that strike the poor simultaneously? And can such extended measures better inform effective and integrated policy responses? Research on joint Environmental and Natural Resources (ENR) and poverty issues is rich, and has contributed to bringing the poverty-environment nexus to the fore. Yet, no widely used multidimensional poverty measure identifies *who* and *how* the socio-economically poor people are affected by ENR-issues, at a large enough scale, and in ways that can respond to and inform public policies over the medium term. This paper sets out how such a measure could be built. In particular, it sets out how to include indicators of ENR deprivations into the profile of the joint deprivations people experience. These deprivation profiles could then be used to compute multidimensional measures using the Alkire Foster (AF) methodology, with the difference that these would now encompass a subset of pertinent ENR deprivations. The paper clarifies the ENR data requirements for developing and analysing such a measure empirically.

Keywords: Multidimensional Poverty Index; Measurement; Environmental and Natural Resources; Poverty-Environment Nexus; Sustainable Development Goals.

JEL classification: D63, I32, O15, Q51, Q56

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Introduction

The Sustainable Development Goals (SDGs) set out an integrated development agenda in which economic, social, and environmental dimensions are to be advanced together. The SDGs further named the reduction of poverty in all its forms and dimensions as the greatest global challenge of our time. How can multidimensional poverty measures – that currently encompass social and economic dimensions – be extended to include environmental deprivations that strike the poor simultaneously? And can such extended measures better inform effective and integrated policy responses? That is the topic of this paper.

Poverty-environment linkages are complex and have been conceptualized in a multitude of ways (Dasgupta *et al.* 2005; De Sherbinin, *et al.* 2007; De Sherbinin *et al.* 2008; World Bank 2007; Barbier 2010). While the perspective of a "two-way environment-poverty trap" has gained credence since the publication of the Brundtland Report in 1987[1], the emerging consensus is that environment-poverty linkages are asymmetric: poverty may cause damage to the environment and to natural resources to some extent, but the degradation of the environment and natural resources (ENR) exerts a disproportionately large impact on the poor (Shah 2009). There is an increasing amount of evidence of these linkages (DFID *et al.* 2002; UNDP *et al.* 2005; World Bank 2008).

Many studies argue that poor people are particularly vulnerable to natural disasters and to environmental degradation, and that they are more dependent on natural resources and assets than non-poor people, although specificities vary. Studies addressing social vulnerability suggest that a household's socioeconomic status tends to affect its level of vulnerability to ENR degradation (Adger 2006; Brouwer *et al.* 2007; Cutter *et al.* 2009). Several studies support the idea that poor people are extra vulnerable to environmental hazards (Agola *et al.* 2014, Dash and Morrow 2007; Masozera *et al.* 2007; Peacock *et al.* 2000). As Agola *et al.* (2014: 15) state it: "one main link between environment and poverty revolves around environmental disasters, and hence the need to reduce the poor's vulnerability to environmental hazards." Poor communities are also argued to be ecologically marginalized, as they are concentrated in socially and environmentally fragile areas (Sen 2003; Watmough *et al.* 2016; von Braun *et al.* 2013). Many socio-economic poverty measures show that the majority of the world's poorest still live in rural areas (Alkire *et al.* 2014) and a sizeable proportion of

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[1] Brundtland Report is available *here*.

these rely upon natural resources and ecosystem services for subsistence and income generation (Barrett 2005; Barbier 2010; Pingali *et al*. 2014). As specified below (Section 3), the Sustainable Development Goals (SDGs) explicitly aim at integrating ENR in poverty alleviation programmes. How could multidimensional measures across the poverty-environment nexus support this agenda?

Research on joint ENR and poverty issues is rich, and has contributed to bringing the poverty-environment nexus to the fore. Yet, as Angelsen *et al*. (2011: 1) notice, though environmental resources are important to millions of poor households in developing countries, "there is not an established right way to systematically collect data that convey their importance". The reason lies probably in the fact that assessing social ENR-related vulnerability at a territorial level entails several challenges, given the heterogeneity of the ways people's livelihoods depend on ENR and cope with ENR variations (Dumenu and Obeng, 2016; Graziano and Rizzi, 2016; Martin *et al*., 2016). One important gap needs to be filled: no high-profile poverty measure so far combines global data on socio-economic human deprivations and environmental deprivations experienced by the same population in the same time period. That is, no widely-used multidimensional poverty measure identifies *who* and *how* the socio-economically poor people are affected by ENR issues, at a large enough scale, and in ways that can respond to and inform public policies over the medium term. Such information would be useful for understanding poverty in all its dimensions and informing integrated policies of targeting, policy design and resource allocation, policy coordination, monitoring, and evaluation (see Galizzi and Herklotz 2008). This raises the important question whether it is possible to develop such a measure.

This paper sets out how such a measure could be built. In particular, it sets out how to include indicators of ENR deprivations into the profile of the joint deprivations people experience. These deprivation profiles could then be used to compute multidimensional measures using the Alkire Foster (AF) methodology, with the difference that these would now encompass a subset of pertinent ENR deprivations. While it is possible in theory, in practice however, as in so many cases, the data are limited. The paper clarifies the ENR data requirements for developing and analysing such a measure empirically, but stops short of canvassing existing data sources.

While the global Multidimensional Poverty Index (MPI) and some national MPIs include some ENR-related indicators such as indoor air pollution (Global MPI) or waste management (national MPI of El Salvador) and lived environment (Chile), there is much more to be done.

The paper is structured as follows. Section 1 presents the methodology and properties of the MPI. Section 2 outlines the conceptual, computational and data requirements underlying the methodology and properties of the MPI. In section 3 we specify the normative framework for a joint poverty-ENR analysis. Section 4 constitutes a propositional framework gathering the components of ENR that affects multidimensional poverty. Section 5 offers an overview of the possible options. In section 6, we study the opportunities and challenges related to each option, with particular emphasis on the possible ways to integrate ENR *within* the MPI. Section 7 suggests furthers steps and research avenues.

1. The MPI: Methodology and properties

The Alkire Foster methodology of multidimensional poverty measurement developed by Sabina Alkire and James Foster (2011), is a flexible methodology that can be used to measure poverty and wellbeing, among other multidimensional outcomes across different dimensions and parameters or specifications. Building on the Foster-Greer-Thorbecke (FGT) poverty measures, it involves constructing a deprivation profile for each person, showing the different types of deprivations they experience at the same time across a fixed set of indicators. The weighted deprivation profiles are analysed to identify who is poor, and then used to construct a multidimensional index of poverty, the MPI.

The AF method relies upon Sen's conception of poverty as capability deprivation (Sen 1992, 1993). The specific aim of the AF method is to shed light on the joint distribution of multiple deprivations the poor experience within a society. More precisely, the AF method aims to reflect the breadth, depth and severity of multidimensional poverty. These three aspects of multidimensional poverty are respectively reflected in three measures, whose generic formulation is given by

$$M_\alpha=\mu(g^\alpha(k)) \quad \text{for } \alpha\geq 0 \qquad (1)$$

In these three measures, the AF method extends the Foster-Greer-Thorbecke (FGT) unidimensional poverty measures by using a dual cut-off identification strategy. The first cut-off is the deprivation cut-off, which identifies whether a person is deprived with respect to a specific dimension; the second cross-dimensional poverty cut-off (specific to the multidimensional context) defines how widely deprived a person must be in order to be identified as poor (see Alkire and Foster, 2011).

The incidence and the breadth of poverty are reflected in the Adjusted Headcount Ratio (M_0), which multiplies the proportion of the population identified as multidimensionally poor (H, the headcount ratio) by the average share of weighted dimensions in which people are deprived (A, the intensity or breadth of poverty). When data are cardinal, the depth of poverty is reflected in the Adjusted Poverty Gap (M_1), which multiplies M_0 (= H x A) by the average poverty gap across all dimensions in which poor persons are deprived[2] (G, the depth of poverty). The severity of poverty is reflected in the Adjusted Squared Poverty Gap (M_2), which multiplies M_0 (= H x A) by the squared deprivation gap across all dimensions in which poor people are deprived (S, the severity of poverty). As many poverty indicators are binary, ordinal or ordered categorical (such as water, sanitation, access to electricity, child mortality, child school attendance), all policy-relevant empirical applications to date use the Adjusted Headcount Ratio (M_0).

A prominent implementation of the Adjusted Headcount Ratio is the Global MPI. This indicator was developed by Alkire and Santos (2010) in collaboration with UNDP's Human Development Report Office and has been reported annually in the Human Development Report since 2010 (see Alkire and Santos 2014). The Global MPI, which consists of ten indicators grouped into three dimensions (education, health and living standards), is internationally comparable: it is computed using the same parameters for all countries. Updated in June 2017, the current MPI covers 103 countries in total, encompassing 5.4 billion people (76% of the world's population). Of this proportion, 26.5% of people (1.45 billion) are identified as multidimensionally poor.

The global MPI has been mapped at a subnational level[3]: "The Global MPI 2015/16 […] maps a total of 990 subnational regions across 78 countries. These poverty maps cover 98.5% of MPI poor people. That is, thanks to improved DHS/MICS and national data, OPHI maps the MPI conditions for 4.8 billion people, of whom 1.5 billion are MPI poor." (Alkire and Robles Aguilar 2015).

Beyond the global MPI, the Adjusted Headcount Ratio has also been mobilised to compute official national MPIs. This is the case in Armenia, Bhutan, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Honduras, Mexico, Pakistan and Tunisia. For those countries, the national statistics offices use national data, and select parameters reflecting country-specific policy priorities – often building the poverty

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[2] "In words, for a person who is deprived in a given indicator, the normalized gap is the difference between the deprivation cut-off and the person's achievement for the indicator, divided by is deprivation cut-off; if the person's achievement does not fall short of the deprivation cut-off, the normalized gap is zero. The average poverty gap is the mean of poor people's weighted normalized deprivation gaps in those dimensions in which poor people are deprived and is one of the partial indices." (Alkire et al. 2015, p. 145).

[3] Click *here* to access the global MPI interactive databank.

measures in active discussion with the relevant sectors and with ministries involved in planning and poverty reduction.

Four properties of the Adjusted Headcount Ratio make it particularly policy-salient: (a) its ability to use ordinal or binary data rigorously; (b) its ability to be decomposed by population subgroups like states or ethnic groups; (c) its ability to be broken down by dimensions and indicators, to show the composition of poverty on aggregate and for each subgroup (Alkire and Foster 2016, *Alkire et al.* 2015, p.21); and (d) its sensitivity to the intensity of poverty among poor people (dimensional monotonicity)[4].

2. Properties of the MPI (M_0) and associated requirements

To expand multidimensional poverty measures to include ENR in an appropriate way, we must ascertain whether there is a good 'fit' between the following three aspects. First, at the conceptual level, one must ascertain that the ENR variables relate to *capability poverty*, and are compatible with basic poverty measurement frameworks. Second, at the computational level, the ENR data should accurately reflect the deprivations of interest, such that a measure or an analysis employing them satisfies the properties of the AF methodology. The third set of requirements relates to the data: do data exist to obtain the joint distribution of MPI and ENR variables for the same units? Are both MPI and ENR variables representative of the same population? Can they both be disaggregated by the same population sub-groups (such as gender, ethnicity or age, for instance)?

2.1 Conceptual requirement: poverty as a capability deprivation

The first question to ask in designing a multidimensional measure is how it will be used for policy. This is done by articulating both its *purpose* and the *space* in which it will be measured. The purpose of a measure includes policy because it covers the ways that the measure needs to be analysed and interpreted. This may include its policy applications, the reference population, dimensions, and time horizon (Alkire *et al.* 2015). If an MPI were to be extended to include ENR dimensions, then its purpose would need to be articulated in a way that social, economic, and environmental dimensions are all policy relevant.

The space of the measure determines whether poverty is measured in the space of resources, inputs and access to services, outputs, or functionings and capabilities (Alkire et *al.* 2015). Due to data constraints, a

[4] For a complete overview of the properties respected by M_0, M_1 and M_2, see Alkire *et al.* (2015), chapter 2; and Alkire and Foster (2011).

measure may use an indicator measured in one space to proxy achievements in another space. In the global MPI, the space that is of central interest is the space of human functionings and capabilities. Functionings are defined as *the beings and doings that people value and have reason to value*, and capabilities are the *freedoms to achieve valuable functionings*. Capabilities and functionings are intrinsically valuable, even though they may also be instrumental to something else. The space of the measure is of tremendous importance when considering ENR since the latter could potentially be resources, inputs, outputs, functionings or capabilities. ENR can be sources of (deprivations in) capabilities and functionings (such as degraded agricultural resources, for instance), and others could constitute functionings or capabilities (such as breathing fresh and unpolluted air). Focusing on functioning and capabilities implies identifying ENR-related constituent components of poverty, understood as deprived beings or doings related to ENR (see Schleicher *et al.* (2016) for a discussion of the distinction between the determinants and constituents of poverty).

One of the purposes of an ENR-extension to the MPI, therefore, is to describe how some ENR-related issues contribute to people's capability poverty directly. This question itself will clarify that many ENR indicators are relevant to joint *analysis* but are not relevant to a multidimensional *measure* because they relate fundamentally to something other than human deprivation. Instead, particular attention will be paid to the *constituents* of poverty, since "the capability approach is not a theory that can *explain* poverty, inequality or well-being; instead, it provides concepts and a framework that can *help to conceptualize and evaluate these phenomena*" (Robeyns 2006: 353, italics added). As a consequence, the ENR dimensions and aspects that could be included within the AF method would reflect valuable activities and states of being that people can actually achieve, given their values and their varying abilities to convert resources into functionings.

2.2 Computational requirement: poverty as a joint distribution of deprivations

Once the conceptual framework is clear, we must ask what kinds of indicators can be used to construct a poverty measure. This section outlines four characteristics of variables that are vital to the power of a multidimensional measure, but which will not be satisfied by all ENR data. First, the variable must be accurate at the level of each person or household – not just on average. Second, it must be an accurate reflection of the unit's achievements over the relevant period (e.g. since the last survey). Third, it must be clear if the variable is relevant for all people and if not, how to treat the non-applicable populations.

Fourth, it must be possible to dichotomize the variable into deprived and non-deprived using justifiable thresholds. Understanding these characteristics will greatly accelerate measurement design.

Since the MPI accounts for poverty as a joint distribution of multiple deprivations experienced by the person or household, each indicator included in the index "must be a relatively accurate reflection of the achievements enjoyed by each unit of identification across the relevant period and not simply the achievements enjoyed 'on average' by some group" (Alkire *et al.* 2015: 220). The unit of identification is defined as "the entity who is identified as poor or non-poor (…)—usually the individual or the household" (*ibid.*). As we shall see, the issue of **unit-level accuracy** is an important one when considering ENR together with MPI. While multidimensional measures require the joint distribution of deprivations to be accurate on average, it might be difficult to accurately identify each person's deprivation in terms of ENR, since some of the ENR-related issues occur at a broader level than the individual or household level. Any type of ENR-related data that would integrate a multidimensional poverty analysis should therefore be consistently transformable at the level of the unit of identification, providing reasonable, explicit and legitimate assumption(s) on the way the units of identification are affected by the ENR at stake.

Second, each indicator of the deprivation matrix should reflect deprivations during the same time period: "the indicators should ideally reflect individual achievement levels across the relevant period so that the comparisons are not unduly distorted by seasonal effects or short-term shocks." (*ibid.*) Since one of the main aspects characterizing the ways ENR affect people is the variability across seasons, the choice of the relevant period of observation and the temporality of the household survey questions will be of tremendous importance for assessing the ENR-MPI linkages, especially if changes across time are considered. For example, if there are daily air pollution data, obviously a bad indicator of deprivation over the past year would be the level of pollution on one particular day. But nor might a good indicator be a simple average. Rather, one might identify an individual as deprived if there were air pollution levels above x for y days of the year. Moreover, the fact that ENR-related issues includes both realized deprivations (such as air pollution, for instance) and potential *threats* of future deprivation (related to climate change, for instance) implies a serious consideration of how to integrate the notion of *risk* within a capability poverty framework, that only takes *effective* (and not potential) deprivations into account. We discuss this important issue in section 4.2.3.

Unit-level accuracy requires identifying the applicable population of the achievement under study, that is, "the group of people for which such an achievement is relevant" (Alkire *et al.* 2015: 222). Just like child school attendance does not apply to adults, some ENR achievements might not be conceptually applicable to certain groups of the population. The existence of a potentially non-applicable population can and should be taken into account when building the index. In the selection and definitions of ENR-related dimensions and indicators, we may restrict consideration to universally applicable achievements, construct group-specific poverty measures, or combine achievements that are not universally applicable and test assumptions regarding intra-household (or intra-communities) distribution and/or impact. The third option has been chosen when constructing the global MPI (Alkire and Santos 2010 and 2014). We will return to this in section 6.

Within the M_0, the joint distribution of deprivation is computed through a censored deprivation matrix (whose columns are the deprivations and lines are the units of identification experiencing these deprivations jointly) containing binary values (see Alkire and Santos 2010, 2014). This implies that ENR indicators must be transformable into meaningful binary indicators that separate people who are 'deprived' from those who are non-deprived. In some cases, such as air pollution scientific guidance can be drawn upon to inform and justify these cut-offs; in other cases, determining cut-offs for ENR variables in terms of human deprivations will be a novel step.

2.3 Data requirements: Micro-data, matching, and representativeness

Even if all of the variables are perfectly configured, there is still one more consideration, which will be further elaborated below (see section 6.2), which are the data requirements when ENR data come from a separate data source than poverty data.

The main data used for multidimensional measurement (and particularly for M_0) are micro data, defined as "the unit-level data containing responses that each unit of analysis (…) provided." (Alkire *et al.* 2015: 217) The three most common micro data sources are censuses, household surveys, and administrative records—also called register data. Multidimensional poverty measures typically rely on multi-topic household surveys, which collect information with one survey instrument using a sample frame that has been defined to capture a diverse set of topics; many are also made from censuses.

ENR data come from various institutions, using various methods, classification and concepts: statistical surveys; environmental monitoring; researchers' datasets; remote sensing and mapping, global and international sources. For most ENR data, transformation will be needed in order to reach the individual or household unit of level of identification. However, not all data are transformable into micro-units.

When ENR data pertain to larger areas, all households in each area will be coded as deprived or non-deprived. As this is a new extension for multidimensional poverty measures, it has to be undertaken and justified with methodological rigor. For example, coding all households in a village as deprived in air pollution erases their between-household variation. Yet some persons' functioning may not actually be affected by the deprivation – they may have air masks or use air cleaners. So it is not a 'real' deprivation. Strategies will need to be explored to address this – whether it is exploring whether the poverty cut-off is set at such a level that a person deprived in such indicators will not be considered poor unless they also suffer additional deprivations, or recommending improvements to the data in a future period, or using the poverty cutoff to censor deprivations that may not reflect poverty.

Another issue is that persons in a community may have different exposure due to occupation. Residents in a rural area may all be coded as deprived if there is soil degradation but actually in the last period, this only affected farmers, and certain fields more than others; furthermore, the percentage of persons affected in different population clusters can differ. So does one use a census (perhaps several years ago) to adjust, or use type of housing from remote sensing to 'guess' occupation or some other strategy? In this way, the accuracy of some area-wide deprivations will need to be probed from different angles, and new strategies may be introduced in order to improve accuracy, but the potential bias of these new strategies must be scrutinized. We will return to each of these issues but at the moment we now turn to develop more extensively the conceptual framework for ENR variables.

3. Normative framework: the SDGs

While the above-mentioned MPI requirements help us delineate the ENR dimensions and indicators that could consistently be integrated within a multidimensional poverty analysis relying upon the AF methodology, they do not constitute a sufficient basis for justifying the normative choices that will be needed in order to integrate ENR variables. Indeed, the choice of indicators and dimensions cannot be neutral, since values and normative conceptions of poverty and ENR will guide the selection. "There are usually plural desiderata for a measure, and these must be taken into account within a coordinating normative framework" (Alkire *et al.* 2015). Therefore, it is of tremendous importance to be explicit about the normative purpose and judgements underlying these choices.

A necessary resource for such a normative framework at present are the Sustainable Development Goals (SDGs, UN General Assembly 2015), given their implicit support for the integration of ENR with analyses of multidimensional poverty. While the MPI plays an important role in the assessment of the MDGs, an enhanced MPI integrating ENR in the analysis should be able to assess whether—at least some of—the SDG targets have been reached (Alkire and Sumner 2013). It would also support integrated multisectoral policy responses. In addition to what the global MPI already addresses (see Alkire and Santos 2014), Table 1 identifies additional goals and targets within the SDGs that could be addressed by an enhanced MPI, provided that they are adequately conceptualized and articulated within the AF method, that is, provided that their transformation into dimensions and/or indicators respects the conceptual, computational and data requirement presented above.

As there are 231 indicators related to the SDG targets, an assessment of all indicators should be undertaken to determine their linkage to the MPI and that task is beyond the scope of this paper. However, it is already clear that human and environmental conditions are viewed side-by-side in the SDGs, and it would be natural to study their interlinkages and patterns of joint deprivation more fully, in the way that an enhanced MPI could offer.

Table 1 – Sustainable Development Goals and Indicators to be potentially related to the MPI

Goal	**Targets/indicators (overview)**[5]
Goal 1	1.4. **Equal right to assets** 1.5. **Exposure/vulnerability to climate-related events**
Goal 2	2.1. **Food Security** 2.3. **Agricultural productivity**
Goal 3	3.9. **Illnesses from hazardous chemicals and air, water and soil pollution and contamination**
Goal 4	4.7. **Education to sustainable development**
Goal 5	5.a **Give women equal rights to assets**
Goal 6	**Water-related issues**
Goal 8	8.8**. Promote safe and secure work environments for all workers**
Goal 9	**9.9.1. Leaving within 2km of an all season road**
Goal 11	11.5. **Number of deaths and the number of people affected and substantially decrease the direct economic losses (…) caused by disasters** 11.6 **Reduce the adverse per capita environmental impact of cities**
Goal 12	12.2. **Sustainable management and efficient use of natural resources**
Goal 13	13.1. **Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries**.

5 The goals, targets or indicators selected in the table are explicitly addressing ENR-related aspects of poverty.

Goal 14	14.4 **Effectively regulate harvesting and end overfishing**
Goal 15	15.3 **Combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods** 15. 9 **Integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts**
Goal 17	17.18 **Increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts.**

4. Components of ENR pertinent to poverty analyses

Integrating ENR within a multidimensional poverty analysis requires choices to select from within the vast array of components and subcomponents of ENR, those that are normatively, theoretically and methodologically relevant, and meet the requirements presented in section 2. The literature on these is vast and contested, and there are many possible avenues to enter this discussion such as livelihoods, health, beauty, culture, and long-term sustainability. Drawing on an extensive reading of the relevant literature, this section proposes a taxonomy of ways that ENR affect people's capabilities and functionings. It does so in order to provide a conceptual basis for "putting the capability approach in practice" (Robeyns 2006) regarding ENR-related issues. In line with the capability approach, the components have been defined in such a way that we can reasonably assume that they are widely valued by most people, meaning that being deprived in these components would reflect more 'unfreedom' for most people.

The taxonomy reflects the points already covered: the properties of the MPI and associated requirements (see section 2) as well as the normative objectives for analysing enhanced MPI (see section 3). In addition, we have analysed a broad literature describing the poverty-ENR linkages and we have studied several institutional frameworks that have attracted a partial yet enduring consensus and associated legitimacy in the field of ENR and livelihoods (well-being, quality of life, poverty). We first briefly present these frameworks and the way they have inspired our taxonomy (4.1). We then detail the taxonomy, which we have designed to be specifically anchored within a capability poverty perspective (4.2).

4.1 Widely recognized frameworks addressing poverty-ENR linkages

Besides the SDGs, we scrutinized the Millennium Ecosystem Assessment (MEA, MEA 2005), the Sustainable Livelihoods Framework (SLF, Scoones 1998, DFID 1999, DFID *et al.* 2000), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, Díaz *et al.* 2015), the World

Bank report "Poverty and the Environment" (World Bank 2008), the UN Framework for the Development of Environmental Statistics (FDES 2013), the Working Group II contribution to the Intergovernmental Panel on Climate Change Fifth Assessment Report (WGII AR5) (IPCC 2014), and the Environmental Performance Index (EPI, Hsu *et al.* 2016). These are not exhaustive, and each of these covers a slightly different scope, has many points of nuance, and there are both overlaps and differences in emphases across them that this section cannot do justice to. What we did try to do was distil from each of these what aspects of ENR they discuss as being relevant to what we are calling multidimensional poverty.

The *Millennium Ecosystem Assessment* (MEA 2005) offers a state-of-the-art scientific appraisal of the conditions of and trends in the world's ecosystems and the services they provide. This assessment, conducted by more than 1,300 experts worldwide from 2001 to 2005, studied the consequences of ecosystem change for human wellbeing: "changes in ecosystem services influence all components of human well-being, including the basic material needs for a good life, health, good social relations, security, and freedom of choice and action" (MEA 2005: 49). In the MEA, four categories of ecosystems functions are distinguished: provisioning (e.g. food, water, fibre, fuel); regulating (e.g. climate regulation, water, disease); cultural (e.g. spiritual, aesthetic, recreation, education); supporting (e.g. primary production, soil formation). These different functions address both the means of subsistence provided by nature (supporting and provisioning function), health aspects (namely related to air and water pollution, e.g. regulating functions) and issues related to risk and vulnerability (regulating and risk functions). The *role of institutions* is stressed as of tremendous importance for developing local ecosystem management strategies, promoting transfer of skills and knowledge among regional groups, and eventually stressing the importance of ecosystems to improving the basic human capabilities of the poorest. While the *space* of the MEA framework is not properly functionings or capabilities, it though considers "freedom of choice and action" (defined as the opportunity to be able to achieve what an individual values doing and being) as the ultimate outcome influenced by ecosystem services. In that sense, considering the MEA appears highly relevant when developing an ENR-enhanced multidimensional poverty analysis based on the capability approach.

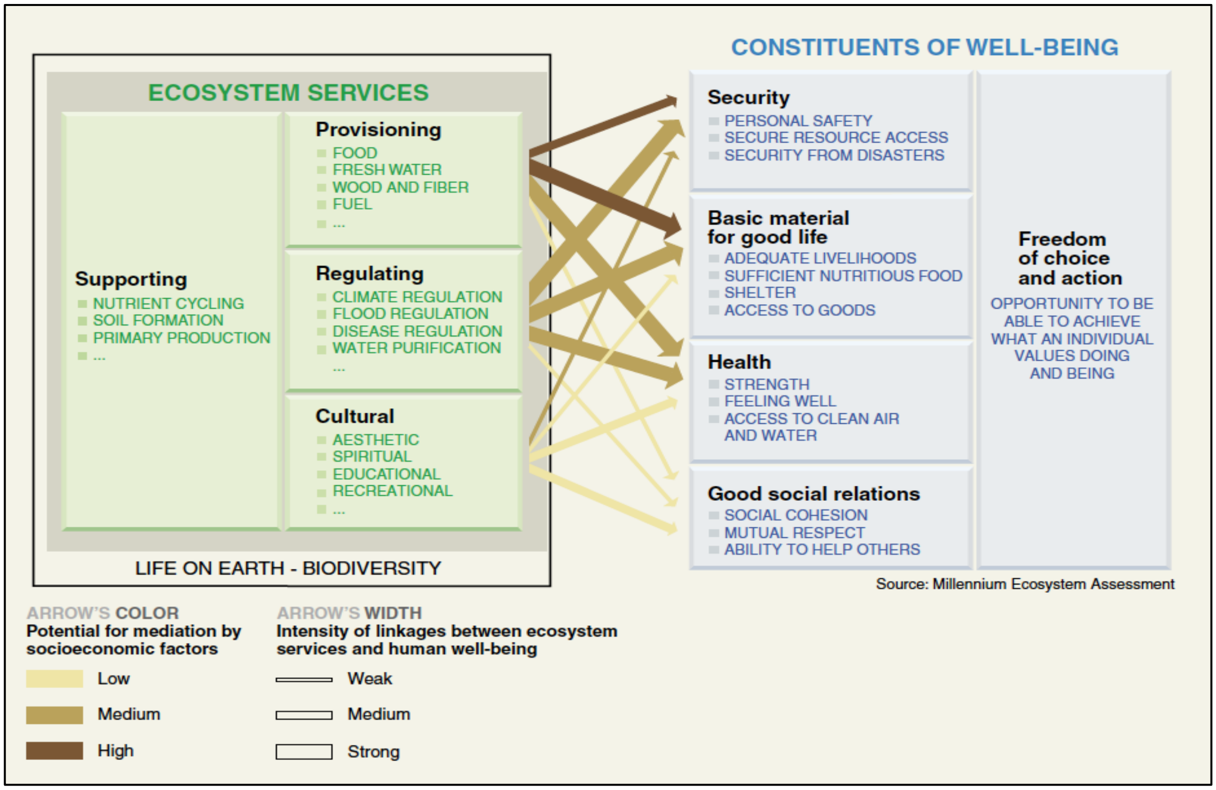
The *Sustainable Livelihoods Framework* (SLF, DFID 1999, DFID *et al.* 2000, Chambers and Conway 1992) provides another widely recognized framework addressing the ENR-poverty nexus. "A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base." (DFID *et al.* 2000)[6] The SLF analyses livelihoods in their *vulnerability context* (the external uncontrollable factors that influence people's assets and livelihood opportunities), and is built upon the distinction between *livelihood resources* or *assets* (which encompass different types of 'capital'), whose combination result in the ability to conduct *livelihood strategies* and associated *outcome* (Scoones 1998). Five types of capital constitute the livelihood resources (see DFID 1999, Scoones 1998, DFID *et al.* 2000): 1) human capital (skills, knowledge, ability to labour, good health); 2) social capital (social networks, membership of formalized groups and relationships of trust, reciprocity and kinship); 3) natural capital (natural resource stocks from which resource flows and services useful for livelihoods are derived, i.e. land, forests, marine/wild resources, water, air quality, erosion protection, storm protection and biodiversity, …); 4) physical capital (basic infrastructure and producer goods needed to support livelihoods); 5) financial capital (for example, savings, credit, cash income). What is interesting in the SLF from a capability perspective is the emphasis put on *the vulnerability context*, which echoes the notion of 'insecure functionings' developed by Wolff and De-Shalit (2007), that we discuss more precisely below. This vulnerability context is of particular pertinence when considering the way ENR affect peoples' livelihoods.

The International Platform on Biodiversity and Ecosystem Services (IPBES) has been developed in the wake of other international assessments, such as the MEA and the Intergovernmental Panel on Climate Change (IPCC). It was designed to "proactively develop assessments matched to policy needs, and to support capacity building across scales and topics … Conceptual frameworks, in the context of IPBES, might be described as 'a concise summary … of relationships between people and nature." (Díaz et al. 2015) The very first goals of the platform are conservation and sustainable use of biodiversity, long-term human well-being and sustainable development.

As illustrated below, the framework includes primary interlinked elements representing natural and social systems (Díaz *et al.* 2015): nature, the benefits that people derive from nature (which includes detrimental and beneficial effects of nature on the achievement of a good quality of life), anthropogenic assets (built infrastructure, health facilities, knowledge, technology and financial assets), institution and governance

[6] Let us notice that the IFAD Multidimensional poverty assessment framework tackles directly resilience aspects (see IFAD 2014).

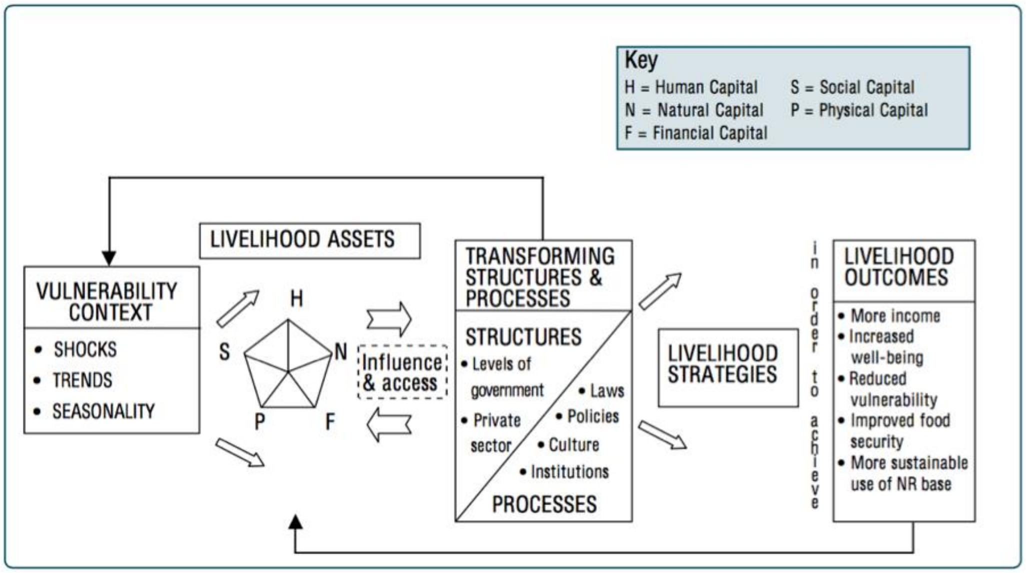
Figure 1 – Illustration of the MEA framework



Source: MEA 2005, p.vi.

systems and other indirect drivers of change (relate to the ways in which people and societies organize themselves and their interactions with nature at different scales); direct drivers of change, which can be natural (beyond human control, such as natural climate, weather patterns and extreme events) or anthropogenic (such as, for instance, climate change produced by anthropogenic carbon emissions, pollution of soil, water or air, and species introductions); and a good quality of life. While this framework does not directly address the relationships between natural and social systems in terms of capabilities and functionings, it though identifies a series of factors that are constitutive of the ENR-livelihood nexus: particularly, it stresses the role of institutions and anthropogenic drivers in the way ENR affect people's freedoms and livelihoods.

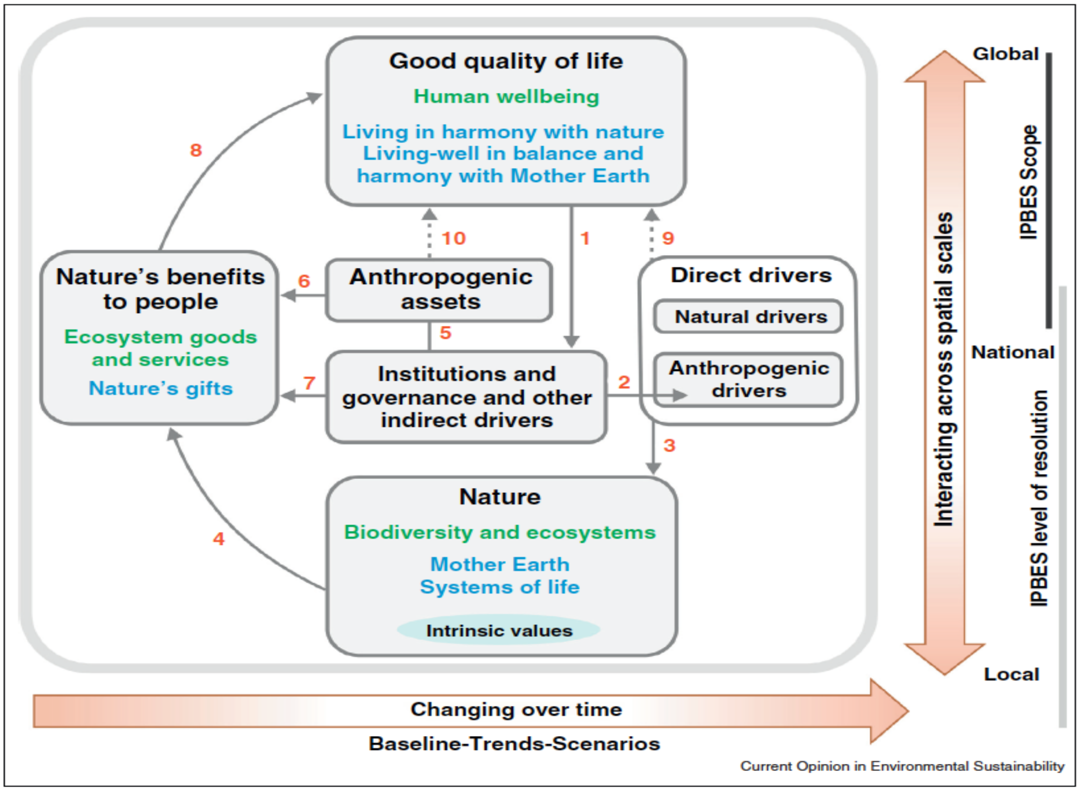
Figure 2 – Sustainable Livelihood Framework



Source: DFID 1999, p.1.

The *Intergovernmental Panel on Climate Change* also provides an important framework indirectly addressing the ENR-poverty nexus. "The assessment of impacts, adaptation, and vulnerability in the Working Group II contribution to the IPCC's Fifth Assessment Report (WGII AR5) evaluates how patterns of risks and potential benefits are shifting due to climate change. It considers how impacts and risks related to climate change can be reduced and managed through adaptation and mitigation. The report assesses needs, options, opportunities, constraints, resilience, limits, and other aspects associated with adaptation." (IPCC 2014: 3) Focusing on climate change, the report brings important knowledge regarding its impacts as well as societies' vulnerability, exposure and coping capacity. Again, if the inclusion of ENR within multidimensional poverty analyses implies broadening the scope of capabilities to the notion of risk, in a perspective of unsecure functionings (Wolff and De-Shalit 2007), the risk factors emphasized in the IPCC's Fifth Report are worthwhile taken into account. The report recognizes that "people and societies may perceive or rank risks and potential benefits differently, given diverse values and goals." (*ibid.*)

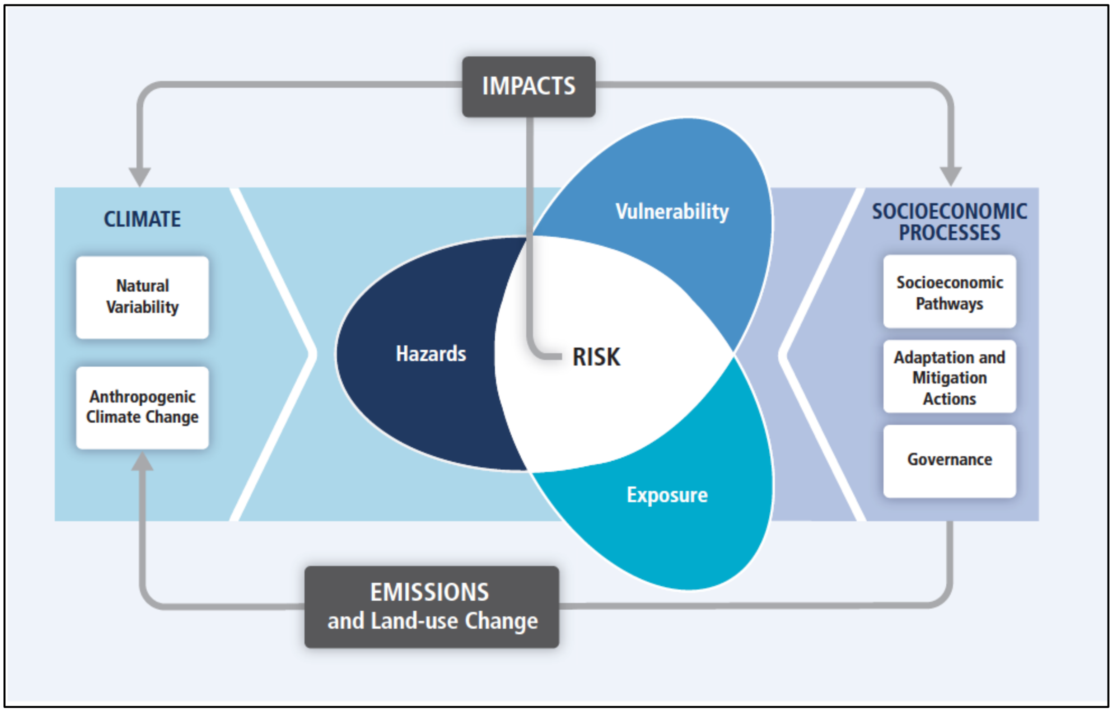
Figure 3 – IPBES Framework



Source : Díaz *et al.* 2015, p.5

The *World Bank report* (2007), entitled "Poverty and the Environment. Understanding linkages at the household level", stands high among the international institutional initiatives that systematically address the poverty-environment nexus. The report analyses the poverty-environment nexus in terms of *assets* (Barrett 2005). The analysis relies upon the assumption that household welfare depends on assets the household has access to or owns, on the returns (known and uncertain) to these assets and on exogenous shocks (linked to natural disasters, death, gifts, or macro market changes) (see figure 5 below). Several key conclusions are stressed (see World Bank 2007: 9 and following). The following are worthwhile considering in a capability approach to multidimensional poverty: *environmental incomes matter to the poor* (as ENR constitute an important source of subsistence and of insurance during times of need); policy reforms are needed to prevent more resources degradation; *health outcomes are strongly linked to the environment in poor countries*; public investment in environmental infrastructure should target poor communities rather than poor households, because investment in clean water and sanitation creates positive externalities for household health; the *lack of public information* about the health impacts of poor water quality and exposure to indoor air pollution may reduce the demand for better environmental quality and limit household behavioural responses; *community-based natural resource management yields a measurable improvement in household welfare*, stemming from increased economic activity, investment in community infrastructure, and improved management of resources.

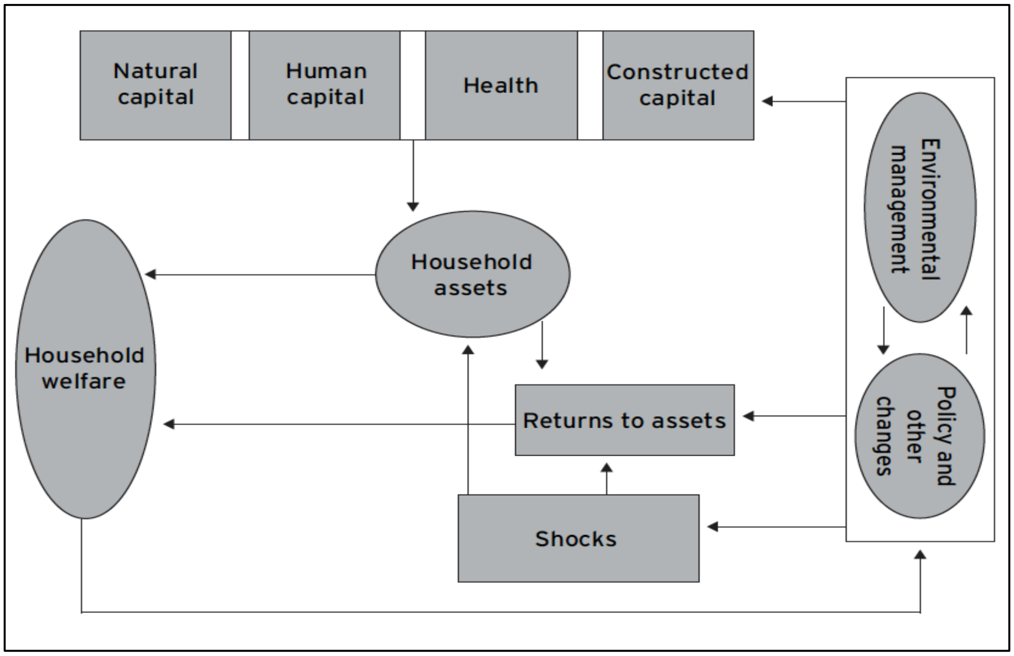
Figure 4 - Illustration of the core concepts of the WGII AR5



Source: IPCC 2014, p.3

The *Framework for the Development of Environmental Statistics* (FDES, UNSD 2016) is the revised version of the original FDES published in 1984 by the United Nations Statistics Division (UNSD). The FDES 2013 organizes environment statistics into six components (broken down into sub-components and statistical topics). The six components include: environmental conditions and quality; the availability and use of environmental resources and related human activities; the use of the environment as a sink for residuals and related human activities; extreme events and disasters; human settlements and environmental health; and social and economic measures to protect and manage the environment (see UNSD 2016: 19, §1.12). By enumerating a series of constitutive elements of the relationships between human activities and ENR and by providing statistics on these elements, this framework constitutes a potentially fruitful data source for concretely integrating ENR within a multidimensional poverty analysis.

Figure 5 - Poverty-Environment Linkages at the Household Level



Source: World Bank 2007, p.5

The *Environmental Performance Index* (EPI), developed by the Yale-NUS College and the Yale University, ranks countries' performance on high-priority environmental issues in two areas: protection of human health and protection of ecosystems. "Within these two policy objectives the EPI scores country

Figure 6 – The 2016 EPI Framework

Source: Hsu *et al.* 2016, p.27

performance in nine issue areas comprised of 20 indicators (see Fig. 6). Indicators in the EPI assess countries' proximity to internationally established targets or, in the absence of agreed-upon targets, how individual nations compare relative to the best performing countries" (Hsu *et al.* 2016). The main reason why we consider this framework lies in its environmental health-related indicators. Those are of particular interest in a multidimensional poverty perspective.

From the several aspects of ENR covered in the above frameworks and their direct or indirect link with the capability perspective on multidimensional poverty, and considering the properties of the MPI and associated requirements (section 2) as well as the normative objectives for analysing an enhanced MPI (section 3), we have identified *three major recurrent components of ENR* that are pertinent for a multidimensional poverty analysis (we detail those in section 4.2). First, what we call the *"livelihoods"* component relates to the *means of subsistence provided by nature to people*. We subdivide it into three subcomponents: the *material* subcomponent of livelihood refers to both direct subsistence provided by nature (such as food security, depending for instance on soil fertility) and indirect subsistence (such as environmental incomes); the *institutional* subcomponent relates to the ways access to the means of subsistence provided by nature are institutionally organized (collective local management system or land rights, for instance); the *skill* subcomponent relates to the cognitive and practical knowledge people have to sustainably manage ENR. The second component is *"environmental health"* (the expression targets human health affected by the environment), that we subdivide into a *household* subcomponent (indoor pollution, for instance), a *workplace* subcomponent (environmental quality at work), and an *ambient* subcomponent (related to the broader living environment, such as outdoor pollution for instance). The third component is *"vulnerability to natural hazards"* and is subdivided into *exposure*, *coping capacity* and *adaptive capacity*.

Table 2 presents a synthetic overview of the several aspects of ENR-poverty linkages addressed in the institutional frameworks presented above, and organizes them according to the components and subcomponents we have identified.

Table 2 – ENR components related to poverty in several widely recognized frameworks

Subcomponents	Sustainable development goals	Millennium Ecosystem Assessment	Sustainable Livelihoods Framework	Intergovernmental Platform on Biodiversity and Ecosystem Services	Intergovernmental panel on Climate Change	World Bank "Poverty and the environment"	Framework for the Development of Environmental Statistics (FDES 2013)	Environmental Performance Index
Livelihoods								
Material aspects	Goal 6 (water) Goal 12 (sustainable management) Goal 14.4.1 Food insecurity (2.1.2) Goal 15.3 (soil quality)	Provisioning Services	Resources, natural assets	Nature's benefits to people	Impacts of climate change on renewable resources (namely water resources)	Dependency of the poor to natural resources	Availability and use of resources and related human activities. Use of the environment as a Sink for residuals and related human activities.	
Institutional	Secure tenure rights (1.4.1)	Institutionally secured access to all ecosystem services	Transforming structures and processes	Institutions and governance systems and other indirect drivers	Improved land tenure could contribute to vulnerability reduction	Role of policy instruments and reforms (decentralization of resource management)	Social and economic measure to protect and manage the environment.	
Skills	Sustainable development education (4.7) Goal 12		Livelihood strategies: the various strategies people use to make a living and how they cope with stress.	Anthropogenic assets		Knowledge (theoretical and practical) is crucial for sustainable resource use.	Environmental information and awareness / environmental education/ environmental perceptions and awareness	
Environmental health								
Household	Goal 3 (healthy lives) Goal 6 (water) Goal 11 : do you live in your waste ? Food insecurity (2.1.2) Goal 8 (Safe and secure working environment)	Regulating Services		Natural direct drivers (drivers of diseases)	Risk of ill-health and disrupted livelihoods due to direct and indirect impacts of climate changes	Health outcomes Need to include environmental management as a mechanism for preventing sickness	Human settlement and environmental health	Environmental risk exposure Household Air Quality Unsafe Drinking Water Unsafe sanitation
Workplace								
Ambient								Air Pollution / Fine Particulate Exceedance Air Pollution / Exposure to NO2

Vulnerability to natural Hazards								
Exposure	Goal 11 (impacts of disasters) Goal 13.1 (resilience)	Potentially all functions (supporting, regulating, provisioning and cultural)	Vulnerability Context	Natural direct drivers	Exposure assessment		Extreme events and disasters (natural and technological). Environmental protection, management and engagement.	
Coping capacity				Anthropogenic assets	Constraints, limits			
Adaptive capacity			Livelihood strategies		Resilience, adaptation			

Source: authors. The table points out the main ENR aspects of the frameworks presented above that are relevant for our conceptual framework.

4.2 Livelihoods, environmental health and vulnerability to natural hazards: pertinent components of ENR

As mentioned in the former section, the three main intersections that we propose between poverty and ENR are: livelihood, environmental health, and vulnerability to environmental hazards. Like any particular conceptual structure, this is only a facilitating framework, which is in no way to be imposed onto the countries or regions that integrate ENR in a multidimensional poverty measure. The issue of legitimacy and autonomous appropriation of any framework is essential, and this one would necessarily be adapted and improved by users. Anticipating such improvements, the components are defined in a sufficiently general way to be specified further at a national or sub-national level. Just as the AF methodology leaves many key decisions to the user, ours offers some structure while continuing to offer flexibility in order for countries or regions to choose what is technically feasible and politically relevant.

The three components (and associated subcomponents) we propose are shown in table 3, which links the components we have designed, respecting the conceptual, computational, data requirements associated with the AF methodology and normative principles, with the components of ENR that are addressed in the widely recognized frameworks presented above. As previously mentioned, the components have been defined in such a way that we can reasonably assume that being deprived in these components would reflect more 'unfreedom' for most people. Each component and associated subcomponent is presented in detail and justified below.

Table 3 – Dimensions of ENR that might be integrated into an MPI

Components	Subcomponents	Brief outline
Livelihood	This component mostly refers to the **means of subsistence provided by ENR to people.**	
	Material aspects	Refers to the qualitative and quantitative aspects of direct subsistence provided by nature (such as crop food, for instance) and indirect subsistence (such as incomes coming from the sale of ENR on a market)
	Institutional	Relates to the ways access to the means of subsistence provided by nature are institutionally organized (collective local management system or land rights, land tenure, for instance)
	Skills	Relates to the cognitive and practical knowledge people have to sustainably manage and benefit from ENR.
Environmental health	This component addresses the **factors in the environment that can adversely affect human health**.	
	Household (Indoor)	How the members of the household are affected by the ENR-related health problems.
	Workplace	Issues related to ambient factors affecting the worker within the working environment.
	Ambient (Outdoor)	Close environment of the household's habitation.
Vulnerability to environmental hazards	This component addresses the extent to which the unit of identification is **exposed, sensitive and adaptive** to a hazardous event.	
	Exposure	Likelihood of a system (e.g. a community) experiencing particular conditions (Smit and Wandel, 2006).
	Coping Capacity	Extent to which a human or natural system can absorb impacts without suffering long-term harm or some significant state change. (Adger et Winkels, 2014)
	Adaptive Capacity	Ability of a system to evolve in order to accommodate environmental hazards or policy change and to expand the range of variability with which it can cope. (*ibid.*)

It is important to emphasise that the three ENR components proposed here are only one particular way of framing the ENR-related linkages with poverty. Other potentially relevant aspects of the ENR-poverty relationship have been proposed that are worth considering further, such as the importance of ENR in conceptions of poverty, including the cultural and spiritual elements of ENR. Schleicher *et al.* (2016) have drawn attention to cultural aspects, including the "sense of place, belonging and rootedness" that are linked to specific features of the ENR.

The three components identified here aim to capture key ENR-poverty linkages that are *constituents* of poverty and could be included in the MPI. While some elements of ENR might take both a constitutive and determinant role for poverty, the elements of ENR that are purely determinants, instrumental factors or drivers of poverty, should not be integrated within the MPI itself, but should rather be analysed alongside the MPI. It would be interesting to explore further the relationship between the MPI and certain ENR-related determinants of poverty as a future research topic. The next sections conceptually explain and justify our proposal of these three components as potentially relevant for expanding the global MPI. Note that this paper is limited to a conceptual discussion. Selection of potential indicators lies beyond the scope of this paper.

4.2.1 Livelihoods

Livelihoods are deeply affected by the conditions of access to and the use of the "provisioning services", defined as "the products people obtain from ecosystems, such as food, fuel, fibre, fresh water, and genetic resources" (MEA 2005).

Many argue that some kind of command over natural resources (such as land tenure, for example) is essential to the security of people's livelihoods (Frankenberger *et al.* 2001; IPCC 2014). The *Voices of the Poor* (Narayan *et al.* 2000) stress how important environmental assets are to the poor. Since good local organisational and management skills often underpin successful resource management activities (White and Runge 1994; Veit *et al.* 1995), Scherr (2000) suggests that a key indicator of equity in the way natural resources are managed is whether the poor, including women, take part and have an effective voice. In that sense, access to resources such as land should not be seen only from a technical perspective (land quality, soil fertility etc.) but also from a governance perspective (property rights, rights of use, etc.). Assessing the access of the poor to the means of subsistence provided by ENR within an enhanced MPI seems therefore essential. Where this is possible, the material, institutional and skill-related aspects of livelihoods related to ENR are meaningful to account for.

We define the *material* subcomponent of livelihoods as the material conditions of access to and use of the resources needed at the moment they are needed in order for people's livelihoods - to do what they value and have reason to value. Natural resources provide people with living means, directly through natural products and indirectly through "environmental income", that is, income coming from ENR such as forest, fisheries or wildlife (World Bank 2008, Sjaastad *et al.* 2005). In that sense, being deprived in terms of material livelihood would reduce the freedoms of the poor to do things they value. In both case they relate to the material subsistence of people. Since subsistence provided by ENR is very geography-specific, we have designed the component (and subcomponents) so as to provide a context-specific interpretation of it Box 1 below provides examples of SDG targets for each of these subcomponents – this encompasses things like food security, agricultural productivity, land rights, and roads.

As observed in section 4.1, several international frameworks identify the *institutional* aspects of livelihoods as crucial. The SLF stresses the importance of identifying "which government, civic and private-sector institutions operate in a given livelihood setting to determine their relative strengths and weaknesses in delivering goods and services essential to secure livelihoods" (DFID *et al.* 2000: 149). The IPBES includes institutions and governance systems as an important dimension to be taken into account and defines them as "the ways in which people and societies organize themselves and their interactions with nature at different scales" (Díaz *et al.* 2015, p.6). In terms of governance, World Bank (2008) shows that "community-based natural resource management yields a measurable improvement in household welfare, stemming from increased economic activity, investment in community infrastructure, and improved management of resources" (World Bank 2008, p.10). This aspect therefore addresses governance issues of various kinds (collective governance of the commons, land rights security (effective and perceived), fiscal systems, etc.). Institutional aspects of command over natural resources are of particular importance to understand gender inequalities (Scherr 2000). As Box 1 shows, SDG targets relate to rights to economic resources for men and women, as well as to controlling practices such as overfishing.

The *skills* needed to access to the means of subsistence provided by ENR refer to two elements: on the one hand, the skills (cognitive, educational, and physical) people have to access and use ENR in a beneficial and sustainable way, and on the other, the awareness of people regarding the impacts (for themselves) of an unsustainable use of resources (like in the case of overfishing, deforestation, pollution, etc.). These aspects are of particular importance since unsustainable use of natural resources contributes to poverty (Duraiappah 1998). This subcomponent partly refers to what is conceived as the "livelihood strategies" in the SLF: the various strategies people use to make a living and how they cope with stress. It means the knowledge of environmentally sound practices such as sustainable fishing or appreciation of indigenous knowledge and practices.

The combination of material, institutional and skill-related aspects determines the effective possibilities people have to convert ENR into valuable functionings.

4.2.2 Environmental health

The WHO defines environmental health as "the theory and practice of assessing and controlling factors in the environment that can potentially affect adversely the health of present and future generations" (World Health Organization (WHO 1993: 18). For the American National Environmental Health Organization, environmental health is "the science and practice of preventing human injury and illness and promoting well-being by identifying and evaluating environmental sources and hazardous agents and limiting exposures to hazardous physical, chemical, and biological agents in air, water, soil, food, and other environmental media or settings that may adversely affect human health."[7]

Box 1 — SDGs' targets and goals related to the dimension "Livelihoods"*

- **Target 1.4.** "By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance." (*Institutional*)
- **Target 2.1.** "By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round." (*Material*)
- **Target 2.3.** "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment." (*Material*)
- **Target 4.7.** "By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and nonviolence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development." (*Skills*)
- **Target 5.a.** "Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws." (*Institutional*)
- **Goal 6** "Ensure availability and sustainable management of water and sanitation for all." (*Institutional and material*)
- **Target 9.9.** "Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all." (*Material*)
- **Target 12.2.** "By 2030, achieve the sustainable management and efficient use of natural resources." (*Skills, institutional and material*)
- **Target 14.4.** "By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics." (*Skills and institutional*)
- **Target 15.3.** "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world" (*Material*)
- **Target 15.9.** ""

* The words in italic between parentheses relate the subcomponents of the dimensions that are mainly concerned.

As mentioned above, the EPI (EPI 2016) makes environmental health one of the two main elements of its global metrics for the environment, alongside ecosystem vitality. In partnership with the Institute for Health Metrics and Evaluation, the authors of the EPI introduce a set of indicators that assess the environmental health risks associated with exposure to poor air and water quality. This measure replaces the Child Mortality indicator used in earlier EPIs, and is normatively justified on the basis of Goal 3 of the

[7] Available *here*.

SDGs (whose target 3.9 aims to "substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination").

The Working Group II contribution to the IPCC's Fifth Assessment Report (IPCC 2014) emphasises that while "the worldwide burden of human ill-health from climate change is relatively small compared with effects of other stressors, (…) there has been increased heat-related mortality and decreased cold-related mortality in some regions as a result of warming (medium confidence). Local changes in temperature and rainfall have altered the distribution of some waterborne illnesses and disease vectors (medium confidence)" (IPCC 2014: 6). Among the key risks of climate change, all of which are identified with high confidence, span sectors and regions, are the "risk of death, injury, ill-health, or disrupted livelihoods in low-lying coastal zones and small island developing states and other small islands, due to storm surges, coastal flooding, and sea level rise", and the "risk of severe ill-health and disrupted livelihoods for large urban populations due to inland flooding in some regions" (*ibid.*, p.13). Children are particularly exposed (UNICEF 2015).

In a multidimensional poverty analysis, three subcomponents of the environmental health component appear relevant: at the household level (indoor), at workplace, and at the ambient level (outdoor).

Addressing environmental health at the *household level* is crucial for better grasping how the members of the household (especially children and their mother) are affected by the ENR. Indeed, "polluted indoor and outdoor air, contaminated water, lack of adequate sanitation, toxic hazards, disease vectors, ultraviolet radiation, and degraded ecosystems are all important environmental risk factors for children, and in most cases for their mothers as well."[8]. Bruce *et al.* (2000: 1078) stress that "Approximately half the world's population and up to 90% of rural households in developing countries still rely on unprocessed biomass fuels in the form of wood, dung and crop residues. These are typically burnt indoors in open fires or poorly functioning stoves. As a result, there are high levels of air pollution, to which women, especially those responsible for cooking, and their young children, are most heavily exposed." In its report released in October 2016, entitled "Clear the air for children", UNICEF shows that "over 1 billion children live in homes where solid fuels are used in cooking and heating. While outdoor air pollution tends to be worse in poor urban communities, indoor air pollution tends to be worse in rural communities where biomass fuels are more frequently used in cooking and heating due to lack of access to other forms of energy" (UNICEF

[8] Available *here* (consulted 24/05/2016).

2016: 9). It also stresses that "indoor air pollution puts nearly 3 billion people worldwide at risk of ill health and early death" (*ibid.*, p.18).

By considering environmental health *at the workplace*, we aim at addressing issues related to ambient factors affecting the worker within the working environment. The ILO (2001), in its report on "ambient factors in the workplace", defines hazardous ambient factors as "any factor in the workplace which may in some or all normal conditions adversely affect the safety and health of the worker or other person." (p. 2) When assessing hazards and risks related to ambient factors, the ILO preconizes to identify: "(a) what hazardous ambient factors are present or likely to occur, including hazardous substances, ionizing and non-ionizing radiation, hazardous optical radiation, electric or magnetic fields, noise and vibration, and extremes of temperature and humidity, including the work organization; (b) what activities are likely to expose workers and others to the hazardous ambient factors identified, including maintenance, cleaning and emergency procedures." (p.23) Even though these factors, as such, are not at present in the datasets used to generate the global MPI, we should find a way to collect information on exposure to workplace hazards and to environmental diseases at work (see also Lugo 2007).

Another important issue is related to the *workplace* dimension: the impacts of commuting. Depending on the way people go to work, their exposition to environmental health problems (related to particulate matter, ultrafine particles, or black carbon) dramatically varies. While Rivas *et al.* (2017) do not find any systematic relationship between income deprivation and pollutant level (related to commuting), they though observe a modes hierarchy in particulate matter (PM) concentration, where underground shows higher concentration than bus, which shows higher concentration than car. The question to be raised in a multidimensional capability poverty perspective is whether people surveyed *do have the choice* to choose for the least exposed commuting option. This issue could be considered when integrating environmental health related deprivation (see Houston *et al.* 2004). This issue could also be enlarged to *school* for school-age children. Buonanno *et al.* (2013) measured children's exposure to ultrafine particles and to black carbon, and they concluded that, beside cooking activities at home, transportation presented the highest black carbon exposure.

Ambient environmental health refers to the close environment of the household's habitation. It could include specific pollutions such as concentration of fine particulates, or NO_2 within the living area of the household. UNICEF (2016: 60) shows that "around 2 billion children currently live in areas where outdoor air pollution (PM2.5) exceeds international limits", due to factors such as vehicle emissions, heavy use of fossil fuels, dust and burning of waste. The ambient aspects of environmental health are different between rural and urban poor. Regarding the urban poor, as McMicheal (2000: 1117) states: "beyond the traditional risks of diarrhoeal disease and respiratory infections in the urban poor and the adaptation of various vector-borne infections to urbanization, the urban environment poses various physicochemical hazards. These include exposure to lead, air pollution, traffic hazards, and the 'urban heat island' amplification of heatwaves". As for the rural poor, one of the main issues lies in soil and water pollution (Picou *et al.* 2015; Massey 2015).

Human health is also likely to be affected by climate and ecosystem transformation occurring across multiple geographic and time scales (Kovats and Haines 2005). While the results are yet discussed and very uncertain, these impacts might range from increasing transmissibility and range of vectorborne diseases (such as malaria and yellow fever) to undermining nutrition through deleterious impacts on food production and concomitant increases in food prices (Brown *et al.* 2014).

Box 2 — SDGs' targets and goals related to the dimension "environmental health"

- **Target 3.9.** "By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination." (*Household, workplace and ambient*)
- **Goal 6** "Ensure availability and sustainable management of water and sanitation for all."(*Household*)
- **Target 8.8.** "Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment." (*Workplace*)
- **Target 11.6.** "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management." (*Ambient*)

4.2.3 Vulnerability to environmental hazards

Vulnerability to natural hazards perspective is often declared to be fundamental in the ENR literature, for example by Adger and Winkels, who write: "[D]evelopment, if it is to be sustainable in the broadest sense, needs to address underlying vulnerabilities in society and vulnerabilities that are created by unsustainable resource use and exploitation. (…) The vulnerability of a group or individual depends on the capacity to respond to external stresses that may come from environmental variability and change, or from social upheaval and change" (2014, p.206). However, it is not clear how the element of vulnerability which appears so prominently in ENR studies should interface with a MPI.

One of the most in-depth conceptual treatments of clustered deprivations, offered in the book *Disadvantage* (Wolff and De-Shalit 2007), argues well that risk should indeed be a dimension of capability poverty and that it should be considered in approaches to poverty that countenance the joint distribution or clustering of deprivations. More precisely, Wolff and De-Shalit revise the capability approach stating that "what matters for an individual is not only the level of functionings he or she enjoys at any particular time, but also their prospects for sustaining that level." (Wolff and De-Shalit 2007, p.9) They therefore consider that "exceptional risk and vulnerability is itself a disadvantage, whether or not the feared event ever actually happens" (*ibid*.). To them, when considering people's (un-)freedom to achieve functionings, one should not forget the importance of (un-)freedom to *sustain* valuable functionings. This conceptual insight has brought us to include the component of risk (vulnerability to natural hazard) within our multidimensional poverty framework, and impacts the way the notion of risk is made coherent within the timeframe of MPI. Indeed, to state the obvious, poverty measures track people's poverty in the most recent period. For example, an MPI that is updated annually, as in the case of Colombia, reflects the deprivations that each household experienced in the intervening year. Regarding the time horizon, ENR encompasses dimensions that are both present and future. It includes actual instances of realized deprivation (e.g. air pollution, soil degradation, flooding) and also presents conditions that can be interpreted as 'threats' for future changes, like global warming. An extended MPI including ENR would need to assess actual deprivations that strike the poor *in the same* period. And yet anxiety about risk, and real vulnerability to exposure, is also part of the experience of poverty. Hence, regarding the 'future' aspects of ENR related issues, in the same way that some national MPIs include health insurance or crop insurance, it might be possible to assess how people from a same reference group are equipped (institutionally, physically, socially, cognitively), *at the time they are surveyed* or *observed*, to cope with natural hazards. Actually, this conception of risk is already present in the global MPI, with indicators such safe drinking water, which can be interpreted as the proxy to an "equipment" allowing the poor to avoid unsafe water-related health diseases.

The *vulnerability* of people to risk depends on exposure, coping capacity and adaptive capacity (Gallopín 2006; Adger and Winkels, 2014; Akter and Mallik, 2013). While definitions of these terms vary, we offer some description of how we are employing them. *Exposure* "encapsulates the likelihood of occurrence and the impact of an extreme event discrete phenomenon whose influence extends over a particular area with particular characteristics. The characteristics of exposure include magnitude, frequency, duration and areal extent of the hazard" (Adger and Winkels, 2014, p.237). Assessing the probability of occurrence of a hazardous event (storm, earthquake, flood…) would require complex probabilistic models that are beyond the scope of our framework or the collection of modelled probabilities from a reputed data source. As our emphasis is on deprivations that have been experienced in the past period, the key assessment of exposure would require using existing data delimitating the level exposure for various areas, although some 'insurance against risk' kind of variable could be included.

Coping capacity is the extent to which a human or natural system can cope, in the short run, with impacts without suffering long-term harm or some significant state change. This concept is closely related to resilience (that can be observed in physical, ecological and social systems) (Adger and Winkels 2014, Brown *et al.* 2014). What a multidimensional poverty analysis could consistently do is assessing the way people are protected against hazardous events, whose probability is assumed to be equal for the whole population of the studied area. People less protected would be considered as more sensitive or able to cope, within an "equal exposure" area.

Adaptive capacity relates to the long term "ability of a system to evolve in order to accommodate environmental hazards or policy change and to expand the range of variability with which it can cope." (Adger and Winkels 2014: 207). In contrast to the just-defined coping capacity, which refers to a short-term ability to survive to a shock, adaptive capacity rather refers to adjustments in the long term (Turner *et al.* 2003) that can modify the sensitivity and exposure of a system to a disturbance.

When indicating risk and vulnerability, it is very important to stress that vulnerability is socially differentiated. "Virtually all natural hazards and human causes of vulnerability impact differently on different groups in society" (Adger and Winkels 2014: 208). Yet risk and vulnerability are both forward-looking, so how do they reflect the past deprivations that are measured in multidimensional poverty analysis? Since the vulnerability of social groups is partially related to assets endowments, a multidimensional poverty analysis could reflect the fact that even though two persons are exposed equally to an uncertain hazard, the person with less command over resources and/or with less adaptive capacity, is less well-off than the other. Similarly, two persons who have the same deprivation score in the MPI, but live in quite different situations of vulnerability, may have differences that are important to capture in order to inform policy design because the risks will affect behaviours.

The three components and their associated subcomponents appear to cover key paths through which ENR has been viewed in the literature as constitutive of people's capabilities. It thus may be thought of as a starting long-list of potentially relevant items for countries or regions to consider when seeking to integrate ENR within a multidimensional poverty measure.

One might though argue that many ENR-related factors affecting poverty are missing, such as biodiversity (Reid and Huq 2005, Fisher and Christopher 2007). If adequate measures are found for additional important phenomena, it is very likely that they will be used in research, and this may lead to adjustments in future conceptual frameworks.

The next step is to address the construction of indicators of ENR deprivations in these components. The following sections explore several options to combine ENR and MPI, but does not progress to selecting and proposing a definitive set of indicators. Our aim is rather to consider the potential benefits and challenges of possible quantification options, on the basis of the dimensional framework presented in section 4.

Box 3 — SDG targets related to the component of risk or "vulnerability to hazards"

- **Target 1.5.** "By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters"
- **Target 11.5.** "By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations."
- **Target 13.1.** "Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries."

5. Combining ENR and the MPI

Several options exist for combining ENR and a multidimensional poverty analysis. In the specific case of the MPI, these options fall into two broad categories, depending on whether ENR is integrated within the MPI or is analysed alongside the MPI (columns A and B in Table 4). As discussed in section 4, ENR-linked determinants or drivers of poverty should most appropriately be analysed alongside the MPI, whilst the aspects of ENR that are considered to be constitutive of poverty should be captured within the MPI. For the aspects of ENR that are to be captured and integrated within the MPI, this can take two forms, either by developing an additional ENR dimension to be added to the existing MPI, and/or by integrating ENR related indicators within existing dimensions of the MPI (see Section 6.1).

Regardless of whether ENR is integrated within the MPI and/or analysed alongside it, a plethora of potential sources of environmental data exists, which can be grouped into two options (rows C and D in Table 4). The first option is to incorporate ENR-related data stemming from household surveys (questions already part of existing surveys or new questions added to household survey modules) into the MPI. This would allow data on ENR to be collected in conjunction with data on other aspects of poverty, such as health, income, employment, or education. The second option is to use ENR data from sources other than household surveys. These data could, under strict conditions, either be included as new indicators within the MPI through appropriate unit-level transformation, and/or studied alongside the MPI through mapping: "given that the aim remains to reduce poverty, not to measure it, (…) merging GIS data on environmental conditions with household surveys (…) greatly strengthens poverty measurement and the monitoring and impact evaluation of sustainable poverty reduction programmes" (Alkire *et al.* 2015: 218).

The two options should not be seen as 'either/or' options, but rather as complementary approaches. Given that both options have advantages and limitations, using each option to address different problems is likely to provide the best outcome in terms of providing meaningful information to inform policy. Research exercises might also explore the value-added of each combination method.

In a nutshell, data can stem from household surveys or non-household-survey sources, and both can potentially be integrated (under strict conditions) as new indicators within the MPI or analysed alongside the MPI. Four options are therefore possible, which are represented in the table below.

Table 4 – The four possible options to integrate ENR within a multidimensional poverty analysis

	A. To be integrated within the MPI	**B. To be analysed alongside the MPI**
C. Household-Survey data	**1)** Adding ENR-related questions to the questionnaires currently used to compute the MPI.	**3)** Overlaying georeferenced environmental survey data sources with the georeferenced surveys used for computing the MPI
D. Non-Household-survey data	**2)** Transforming environmental georeferenced data in achievements/ deprivations and integrating them as new ENR-related indicators within the MPI.	**4)** Mapping the MPI on a geo-referenced environmental data in order to assess potential correlations.

6. Integrating ENR within multidimensional poverty analysis: opportunities and challenges

The first question that arises when integrating ENR within the MPI is whether to categorise ENR-related indicators within a separate additional dimension, or incorporate ENR-related indicators in existing dimensions. Following Alkire *et al.* (2015), we define dimensions as "conceptual categories into which indicators may be arranged (and possibly weighted) for intuition and ease of communication." (p. 197)

There are three compatible ways ENR components (and associated subcomponents) could be integrated *within* an MPI. ENR could either be included as a separate dimension, or as indicators within existing dimensions, or a mix of both options (part of it would be a new dimension and part of it would be added to existing dimensions). For example, Bhutan's gross National Happiness Index has a dimension on the environment; El Salvador and Chile both include dimensions in their national MPIs that have explicit environmental features. Table 4 below offers an illustration of these several possible ways, on the basis of the ENR dimensions presented in section 4.

Table 5 – Illustrative integration of ENR components within the Global MPI

Health	Nutrition
	Child Mortality
	+ Indicator(s) related to ambient environmental health
Education	Years of schooling
	School attendance
	+ Indicator(s) on skills related to command over resources
Living Standard	Cooking fuel (***already captures indoor environmental health aspects***)
	Improved sanitation
	Safe drinking water
	Electricity
	Flooring
	Assets
	+ Indicator reflecting material aspects of livelihoods related to ENR (related to land ownership or to soil quality, for instance)
+ Risk (Vulnerability to natural hazards)	**Indicator reflecting exposure**
	Indicator reflecting coping capacity
	Adaptive capacity (could encompass all the other dimensions → might not be necessary to add)

Legend: text in straight bold illustrate the addition of new indicators and of a new dimension; text in bold italic shows ENR-aspects that might already been reflected in pre-existing indicators.

The way ENR are integrated within the MPI depends on the relationship that exists between the ENR components and related indicators. If ENR-related indicators are integrated in the index, but the deprivations they proxy are already reflected in other indicators of the MPI, one could have double counting. When done consciously, this double counting might be a way to stress the importance of the dimension. But if one is not aware of the double counting, this might constitute an important bias, namely when analysing and interpreting the ENR contribution to poverty.

We now explore the two possible ways ENR could be integrated *within* the MPI (options 1 and 2 in Table 3). For each option, we start from what already exists in terms of data and techniques, we show the issues related to implementation and suggest possible improvements and new research avenues.

6.1 Adding ENR-related household survey questions to multi-topic household surveys

There are many reasons why household surveys could be a useful and innovative way of obtaining data on the way ENR affect the poor. For Alkire and Samman (2014), high quality multi-topic surveys (complemented by interim lighter surveys) have demonstrated ability to collect the core indicators of human poverty at the individual and household levels.

As far as ENR are concerned, multi-topic surveys could identify which economically and socially poor groups are also the victims of specific ENR conditions. Moreover, the household survey could provide data on specific impacts of ENR on the poor if no other data sources exist in a given country. Furthermore, empirical hypotheses on the causal relations between ENR and poverty could be tested using such data more accurately than with aggregate datasets (for instance on the link between multidimensional poverty and command over natural resources). Finally, the surveys would provide baseline data on the impact of ENR on the poor, together with socioeconomic data: protection against hazards or property destruction due to hazardous events (such as earthquakes, landslides, floods, storms…), for instance, could be decomposed according to demographic sub-populations, location, type and nature of affection, all of which are important information for designing policy.

In order to shed light on the opportunities emerging from the potential integration of ENR consideration within the MPI, on the basis of household-surveys, we first explore the concrete possibilities on the basis of what exist; we then recall the requirements to be met in order to integrate existing ENR-related survey questions within the MPI; finally, we explore possible further steps.

6.1.1 What exists: ENR-related variables in commonly used household surveys

A first step to integrate ENR within the MPI is to look at the existing questions that could be quite easily added to those already covered by the indicators of the global MPI. A first step in that direction was already done in the Human Development Report (HDR) 2011 (UNDP 2011, see Box 4). Since the global MPI is built on the basis of DHS and MICS data for most countries, we look here at the questions, within these surveys, that might potentially address ENR-related issues (this exercise is replicable for any dataset used to compute specific national/sub-national MPIs). These questions being part of the multi-topic survey upon which the MPI is computed, data associated to these questions have the major advantage that they could be easily added to the data already used for computing the global MPI. It would then be possible to compute a joint distribution of the former and the newly accounted deprivations. This merge would be potentially enlightening for better characterizing multidimensional poverty analysis.

Annex 2 gathers the DHS and MICS questions that address issues related to several ENR components presented in our framework (section 4). For instance, data on access to water and land ownership are part of the *material* aspect of livelihoods component, while the land tenure dispositions ("who owns what and how") rather refers to *institutional* aspects of livelihoods. Environmental health is particularly well represented. Air pollution and water quality, which are widely addressed in these questionnaires, are considered in a vast literature as crucial to environmental health. EPI (2016) conceives both as "risk factors" to be tackled in order to mitigate the health effects of environmental degradation. As far as "vulnerability to hazards" is concerned, information regarding the habitat is interesting to shed light on the social differentiation of sensitivity to hazards. Information on the geographical location of houses is also interesting, if linked to georeferenced ENR data, as we shall discuss in section 6.2.

Box 4 —Human Development Report 2011: environmental deprivation through the lens of the global MPI

Considering that the world's most disadvantaged people carry a "double burden", since more vulnerable to environmental degradation must also cope with immediate environmental threats (from indoor air pollution, dirty water and unimproved sanitation), the HDR 2011 made a first step in interpreting environmental deprivations through the lens of MPI. The report considered the indicators already included the global MPI that were linked to the environment. Three indicators were specifically scrutinized: lack of access to modern cooking fuel, clean water and basic sanitation. The aim was to "explore the pervasiveness of environmental deprivations among the multidimensionally poor (…) and the extent of their overlap at the household level" (UNDP 2011: 45).

Globally in 2011, at least 6 in 10 people experienced one environmental deprivation, and 4 in 10 experienced two or more; among the multidimensionally poor, more than 9 in 10 faced at least one deprivation (nearly 90% did not use modern cooking fuels, 80% lacked adequate sanitation and 35% lacked clean water). Most poor suffered overlapping deprivations: 8 in 10 poor people experienced two or more environmental deprivations, and almost one third faced all three deprivations. Unsurprisingly, the report showed the rural poor were more afflicted. The analysis also stressed state- and provincial-level environmental disparities. "Overall, environmental deprivations disproportionately contribute to multidimensional poverty, accounting for 20 percent of the MPI—above their 17 percent weight in the index" (*ibid.*, p.47).

Ordering countries by the share of multidimensionally poor people facing one environmental deprivation and the share facing all three, the analysis also shed light on countries with good environmental performance. For instance, countries with the lowest share of poor people facing at least one deprivation were mainly in the Arab States and Latin American and the Caribbean. In the countries with the fewest multidimensionally poor people with all three environmental deprivations, it was shown that several South Asian countries had reduced some environmental deprivations (namely access to potable water), even as other deprivations have remained severe.

While the results of this analysis are of great interest for policy-makers, the authors of the report very much aware of the precautions to be taken when analysing them. They recognize that "performance on these [three] indicators [do] not necessarily identify environmental risks and degradation more broadly". While the three environmental deprivations were selected as the best comparable measures across countries, the authors are aware that other environmental threats may be equally or more acute at the local or national level. This suggests that an ENR-enhanced MPI would be very meaningful to refine further the understanding of the ENR-poverty nexus.

For the sake of illustration, we select some variables related to the ENR components and associated subcomponents presented in section 4. The selection of these variables constitutes a normative choice (or at least a pragmatic choice having normative implications), as is the transformation of these variables into achievements/deprivation indicators. "As with most measurement exercises, it will be the designers who will have to make and defend the specific decisions underlying the implementation, limited and guided by the purpose of the exercise and other concrete constraints." (Alkire *et al.* 2015: 196) That is why the normative underpinnings of any attempt to integrate ENR and MPI must be made very clear.

6.1.2 Illustrative indicators and associated issues

Adding new ENR indicators within a deprivation matrix on the basis of new survey questions requires satisfying some technical and conceptual conditions and considering some normative choices. First, questions selected must come from the same questionnaire as the one used to compute the joint distribution of deprivations. Otherwise, the merging of data will be required (under specific conditions, as will be elaborated in 6.1.1.3).

Second, the selection of relevant questions must be well justified. For the present exercise, the ENR conceptual framework presented in section 4 constitutes a basis upon which we identify and select the existing DHS questions that could be transformed into achievement/deprivation indicators. This framework is itself guided by the space (functionings and capabilities) and the purpose of the measure (to decrease poverty). In reality, the questions should not only rely upon a conceptual framework but also on empirical observation. The empirical observation is mostly necessary given the geography- and occupation-specificity of ENR issues. In that respect, any ENR indicator integrated within the MPI should first be field-tested.

Indicators are the building blocks of a measure; they bring into view relevant facets of poverty and constitute the columns of the achievement and deprivation matrices. The transformation of survey questions into binary indicators (as must be done when computing M_0 on the basis of a censored deprivation matrix) implies defining deprivation cut-offs. As mentioned in section 1, the deprivation cut-off for an indicator shows the minimum achievement level or category required to be considered non-deprived in that indicator. Defining the deprivation cut-offs is therefore a very normative choice and should be made as transparent as possible. The choice could rely upon international standards, basic minima, deliberative processes or on specific political programs targets.

Table 5 illustrates a possible selection of questions and their transformation into achievement/deprivation indicators, based on illustrative deprivation cut-offs.

Table 6 – Examples of questions transformable into indicators (based on DHS surveys)

Component	Subcomponent	Selected Variables	Indicator transformation
Command over natural resources	**Material**	**HV244** – Own land usable for agriculture **HV245** – Land size	Deprived if no land owned Deprived if land size < 1ha
	Institutional	--	--
	Skills	--	--
Environmental health	**Household**	**HV226** – Type of cooking fuel (*already in global MPI*). **HV242** – Household has separate room used as kitchen	Deprived if cooking fuel is dung, wood, or charcoal. Deprived if there is no separate room used as kitchen
	Workplace	--	--
	Ambient	--	--
Risk (vulnerability to natural hazards)	**Exposure**	**HV024** – Place of residence	Context-specific (deprived if place of residence is identified as risk-prone zone, for instance)
	Coping capacity	**HV213** – Main material of the floor. **HV214** – Main material of the walls. **HV215** - Main material of the roof.	**Deprived** if floor is dirt, sand, or dung **Deprived** if walls are "No walls", "Cane / palm / trunks", "Dirt", "Bamboo with mud", "Uncovered adobe", "Plywood", "Cardboard", "Reused wood", "Trunks with mud", "Covered adobe", "Wood planks / shingles" **Deprived** if roof is "No roof", "Thatch / palm leaf", "Sod", "Rustic mat/plastic", "Palm / bamboo", "Wood planks", "Cardboard", "Metal", "Wood", "Calamine / cement fiber", "Ceramic tiles", "Cement", "Roofing shingles".
	Adaptive capacity	--	--

Each question and associated indicator illustrated here raise normative and technical issues that illustrate what could apply to many other cases when integrating ENR within the MPI. Food security is important, but land tenure is a poor approximation for it; also, land tenure has difficulties in establishing the non-applicable population, as many who do not have land may not be insecure (doctors, teachers, vets, artisans, shop keepers, urban residents). Cooking fuel is vital, but the additional information really required to establish whether cooking fuel generates indoor air pollution is not whether there is a separate kitchen only, but also if there is adequate ventilation for the smoke and fumes. Housing quality surely affects vulnerability for example to storms and heavy rains, but it is not clear that the criteria used here would be distinctive from other housing quality indicators using the existing survey questions. Hence while some DHS/MICS survey questions cover components and subcomponents of ENR as presented in section 4, technical specifications related to the MPI's methodology might limit their use as new indicators to be integrated in the deprivation matrix supporting the computation of MPI.

6.1.3 Beside the technical specifications and the issue of non-applicable population, one problem is very specific to ENR: their occupation- and geography-specificty, which questions the ambition of designing a general ENR-enhanced MPI. Adding ENR-related survey data to multi-topic surveys: further steps

While DHS and MICS ENR-related questions have the advantage of being collected *jointly* with other MPI questions, one can observe (see Annex 2) that these questions are far from exhaustive in covering ENR components and associated subcomponents. Institutional and skills aspects of the "livelihoods" component, ambient and workplace environmental health as well as coping and adaptive capacity to hazards, are not addressed. Moreover, when covered, the components and associated subcomponents are only partially addressed and not all questions are liable to be integrated in the MPI, as shown in the examples above.

It could therefore be interesting to explore other existing ENR-related household survey modules. Such modules exist and are often country- or region- specific (Bhutan's Gross National Happiness Index Survey, Ecuador's Quality of Life survey). However, in many countries ENR data are not fielded within multi-topic household surveys and therefore do not cover the non-ENR aspects of multidimensional poverty (such as health, education, livelihood, or living standards).

Having these ENR-data integrated in the MPI could nonetheless be done following two ways. One could either create an *ad hoc* ENR-survey module to be added to the current survey modules used to compute the MPI. This has been done in Bhutan, in the Gross National Happiness questionnaire[9], in El Salvador, or in Chile's CASEN survey in the most recent wave. Bangladesh Bureau of Statistics has also started including a climate/environment module in their household income expenditure survey and started generating poverty related data from the disaster statistics (disaggregation of damages and losses due to climate related hazards by income quintiles)[10]. In the Dominican Republic, the national household survey was modified integrating a new module entitled "Risk of Natural problems and environmental pollution". These endeavours will definitely be of great interest and are likely to continue being advanced.

Two issues should though be considered when considering adding new questions to household surveys. First, at the policy-making level, the costs of such addition should be assessed. Second, adding new

[9] The GNH is computed building upon the AF methodology.

[10] Available *here.*

questions would probably change the metrics and weighting schemes, which could eventually have a major political effect: would the number of poor´s increase or decrease? Would it be more or less stable in time? These issues should be explicitly addressed.

Yet not every ENR consideration can be grasped through household surveys. Some ENR phenomena are not visible to people, and their impacts lie beyond individuals' awareness (like climate change for instance, of fine particulate concentration). Moreover, surveys can be biased due to the fact that some survey questions rely on people recalling the past. This can be especially severe for reconstructing historical data through recall, especially when discussing risk and hazard events and changes in the severity of conditions. For these reasons, we elaborate the second option, namely of joining information sources, below.

6.2 Integrating non-household-survey data

6.2.1 Opportunities associated with non-household-survey data

Many other sources of environmental data exist that could be integrated with existing MPI data. This opens up a diverse set of opportunities in terms of potential environmental datasets, given that most environmental data are typically collected through other means than household surveys as numerous environmental questions are best answered through other methodologies. The methodologies for collecting environmental data are as diverse as the types of environmental data themselves. In terms of biological field data, collection has traditionally focused on restricted geographical areas, for example collected through vegetation plots, wildlife transects or point counts, which are relatively research effort intensive. However, with the rise and increasing accessibility of remote sensing technologies, most notably satellite sensors, the geographical extent of what can be covered repeatedly, in relatively short periods of time, has drastically expanded and has taken a global reach. Among the multitude of environmental datasets that exists, the ones that are most relevant for potential integration into the global MPI or another large-scale international MPI are those that are (1) georeferenced, (2) available at a high-enough resolution, and (3) have a large spatial extent, being available preferentially at national to global scale. This makes products derived from remotely-sensed data (e.g. satellite images), meteorological data, and environmental risk data, derived through from observation and/or models, particularly relevant in this respect (e.g. global forest cover based on Landsat images; global maps of environmental risks, including floods, droughts and earthquakes; NDVI based on MODIS satellite images as a proxy of agricultural production and to identify specific climatic events). These data are therefore the focus of this section.

Beside remote-sensed data, another pertinent source of information lies in the individual sensors and mobile technologies. Regarding children's well-being and safety, Kinnunnen *et al.* (2016) suggest new areas of research in sensor and social web development to help indicate children's insecurity in their daily environment. If these sensors were applied to children (or any household member) within the surveyed households, it would be possible to collect jointly information related to the poor's environment together with socio-economic data.

While integrating such data into the MPI opens up a large set of opportunities in terms of available datasets, it also requires a careful consideration of potential methodological and technical challenges that need to be addressed, which are elaborated in section 6.3. Furthermore, while some environmental variables are best captured through remote sensing, others cannot be measured in this way, although proxy indicators may be available in some cases. Each indicator therefore requires a careful evaluation of what data sources and methods would be most appropriate for obtaining relevant data and what the implications are, especially in cases where proxy indicators are chosen.

6.2.2 How to integrate non-household-survey data

A prerequisite for integrating data from different sources is that, respecting ethical guidelines to protect respondents, they can be linked spatially, meaning that that they need to be georeferenced (i.e. have GPS coordinates associated with them). This then allows the datasets to be integrated into, and overlaid in, a Geographic Information System (GIS) database. It then allows the environmental data to be manipulated as necessary and extracted based on the point location of the household MPI data.

While many of the recent DHS and MICS datasets have GPS coordinates associated with them, the GPS coordinates for the DHS data are displaced to ensure the confidentially of the respondents. The displacement is applied randomly, such that the positional error of rural areas is up to 5 km and that of urban areas is up to 2 km. In addition, 1% of the rural data points are displaced by up to 10 km (Burgert-Brucker *et al.* 2016). This means that the exact location of the centre of the populated areas surveyed (cluster centroid) cannot be determined. As research on the environmental-poverty nexus develops, it would be desirable to create data integration systems by which poverty data processing teams merge their datasets with environmental data *behind a firewall* (before the data are displaced) in order to provide aligned poverty-environmental datasets based on the exact GPS coordinates of the cluster centroid, which is then re-anonymised[11]. In cases where this is not possible or required, the buffers have to be taken into account when linking DHS and environmental data (Brown *et al.* 2014). While higher resolution environmental data can still be used and processed for this purpose, the calculation of the relevant environmental statistics (e.g. mean, minimum or maximum values) and the extraction of the data should be done considering the buffers.

6.3 Common challenges for indicators design and data integration

Whatever the data source (household-survey or georeferenced non-household-survey), the integration of ENR within the MPI requires paying attention to several conditions and requirements. Section 2 presented the conceptual, computational and data requirements to be met in order to integrate ENR components within the MPI (built as M_0). Conceptually, the space (capability and functionings) and the purpose (decreasing poverty) of the measure should be kept in mind. At the computational level, one should make sure that any indicator chosen respects unit-level indicator accuracy; one should be aware of the applicable population targeted by the chosen indicator (and make explicit any related assumptions); and one should define deprivation cut-offs in such a way that the indicators are meaningful and easily interpretable.

Besides these requirements implied by the MPI, three other issues deserve particular attention when ENR-related data are to be incorporated within a censored deprivation matrix, due to the specificity of ENR, namely issues related to the sampling design and spatial/temporal/spectral resolution.

6.3.1 Sampling design issues

As highlighted earlier, the MPI tends to be computed based on a sample of households in a specific sub-national or national context. Considerations of sample design determine how representative any data sample is at different spatial and temporal scales, as well as according to which variables the sample is representative and what types of heterogeneities are captured. This is especially relevant with regards to integrating environmental and social data within the MPI methodology, as the heterogeneity of the environmental data is likely to follow different patterns to those of social data (Hein *et al.* 2006). This

[11] See ESPA (2015a) for a discussion on the ethical issues related to anonymisation: "Anonymisation is a valuable tool that allows data to be shared, whilst preserving privacy. The process of anonymising data requires that identifiers are altered in some way such as being suppressed, substituted, distorted, generalised or aggregated. A cautionary note is that the process of anonymisation may impact on the usefulness of data. … In this case, overprotection of data can be undesirable." (ESPA, 2015a: 7).

means that the criteria according to which the MPI data sampling is stratified (e.g. administrative boundaries such as provinces or districts) may not necessarily ensure that it captures important environmental heterogeneities and hence, is representative for the environmental data. If for example, the population sample is clustered in areas exposed to a similar level of environmental risk and does not capture the variation in exposure to environmental risk present in the wider population, all sampled household might score similarly in their environmental risk deprivation. In such a case there might not be sufficient precision in the sample to detect any contributions of exposure to environmental risk to poverty. For example, for a province that is half forested and half covered in wetlands, based on data representative at the provincial level one may not be able to state whether the population living in forest is poorer than the wetland population. Also, there may be areas of particular environmental interest – such as a small range of islands – and the population there may not be its own province, but rather belongs to one or more land-based provinces, so in a dataset representative at the provincial level, their poverty cannot be compared with others.

The sampling design that has been applied to determine which households are included in a specific survey varies between data sources as it depends on the purpose of collecting the data. In the case of DHS, the sampling frame was developed to ensure that the selected household are representative of the population at the provincial level and for urban/rural residence in any specific country that is surveyed. This means that the sample size per unit area will vary between countries. Sampling of households follows a stratified, two-stage process: first, the boundaries of so-called rural and urban enumeration areas are delineated by the county's statistics bureau, based on pre-existing geographical areas. Second, 20-30 households are randomly selected within each enumeration area, which constitute the sampling cluster (Brown *et al.* 2006; Burgert-Brucker *et al.*, 2016). These sampling criteria however, might be distinct from those that might influence the heterogeneity of environmental data. For example, with respect to different vegetation types and ecosystems, climatic variables and topography (slope and altitude) are important factors. Meanwhile, the distance to water bodies, levels of precipitation and the conversion of natural vegetation will influence the flood risk of an area.

Whether this matters depends on the question one tries to answer. If one wants to know the deprivations, including environmental, that the population at the district level faces, selecting a household sample representative at the district level, can be appropriate. If on the other hand, one wants to know what deprivations households face living in different ecosystems (forests vs. wetlands) or exposed to different environmental risks (rising seas for island-dwellers), then the sampling should ensure that the household sample is representative of different ecosystems or levels of environmental risk.

If it matters that the sample is representative with respect to environmental considerations, one should retrospectively check whether the distribution of the household sample is biased with regards to the relevant environmental variables. For example, urban centres with higher population density might be over-represented in the sample, while an area of low population density that is exposed to a high environmental risk might be under-represented. If this is the case, there are different ways in which one can potentially address the issue: (1) it might be possible to resample/sub-sample the sampled data to ensure there is no bias with respect to the environmental variables that are of interest; (2) it is worth checking the representativeness of the data at a different spatial scale, e.g. while the data might not be representative at the sub-national level at which it was sampled, it might be representative with respect to the environmental variables at the national or regional level; and (3) the design strategy of future household surveys might be revised, taking into account relevant environmental variables in the sampling frame.

6.3.2 Spatial / temporal / spectral resolution issues

As mentioned above, it is crucial to ensure that the spatial, temporal and spectral resolution of the environmental data is fit for purpose and is compatible with that of the MPI data. This will require a new step in any research methodology section of articles or reports, which argues why the temporal and spatial resolution of the social and environmental data are compatible and describes any transformation of the datasets that was required, and why this was the appropriate transformation for an enhanced poverty analysis and corresponding policy making.

Concerning the selection of the appropriate time frame, many remote sensing sensors collect time repeatedly over time (e.g. Landsat images are taken every 16 days of the same Landsat scene), often providing a large time series of data to select from, especially in places where there is no persistent cloud cover. The new methodological questions in this respect include (as mentioned above) how to aggregate across time to portray ‘deprivations’ in a period that matches poverty – for example, across the last year. Is the best aggregate the mean, or median? Or should maximum or minimum values, in cases where there are a small number of extreme events. For example, with regards to rainfall, the average can be less informative than periods of droughts and floods. Also, how precisely should GIS be mapped to households? The answer to this question has to be justified both in terms of the environmental data and on the human side, to the dispersion of people's activities. For example, if fields are next door to each other a tight matching makes sense, but if average commutes are much longer, the areas required to capture environmental impacts at home and workplace effects might also expand. There also may be certain kinds of environmental conditions that affect only certain households (for example, those using well water) and not others, in which case a survey question (on source of water) could be used to apply the environmental deprivation if wells in their region are contaminated. New conventions are required to prepare the data, and sensitivity tests will be required in the initial phase to establish the sensitivity of final results to the methodological choices made here.

It is worth noting that many environmental variables have considerable seasonal variation, which is important to consider when selecting appropriate indicators and the relevant datasets. Unless capturing seasonal variation is of interest and this is taken into account during data collection (e.g. repeatedly collecting data during the same season and in multiple seasons over time), data collection has to ensure that seasonality is not an issue by selecting appropriate indicators. This means that environmental data might have to be transformed or different datasets have to be integrated (e.g. to obtain yearly average values or extreme events, such as number of severe drought/flood events within a specific timeframe). However, this issue is not restricted to environmental data, but applies to many factors affecting poverty. For example, access to drinking water or the BMI might vary across seasons as they can be affected by precipitation and agricultural production, respectively.

Concerning the temporal aspect of the data, it is also important to consider potential time lags between a specific environmental variable and its impact on people (e.g. Shively *et al.* 2015). As data stemming from the same household survey might not be able to take time lags into consideration (except if questions are asked about events in the past), it highlights the importance of conducting repeat surveys with the same households. Repeating household surveys in short time intervals (e.g. yearly or more than once a year) is unlikely to be feasible at a large scale (e.g. national) for extensive survey modules, such as the DHS. This makes remote sensing data, models and other datasets for which appropriate time-series data are available particularly relevant for such purposes.

6.4 'Balance': ENR in geographically diverse regions

A common practical issue that will arise is how to select the dimensions of ENR, and we are now able to articulate that concern. The political units of poverty measurement will contain a set of very precise and pressing environmental problems. But these will differ across regions and population groups. Soil degradation or deforestation may be a problem in the upper regions, whereas one particular belt may have a problem such as arsenic or a recurrent pest infestation or wildlife damage to crops, and urban areas may face air pollution, and the coastal populations may face overfishing or flooding or tsunami. How can such a diverse set of environmental considerations be included in a permanent MPI?

The danger given the proceeding analysis is that those ENR variables will be selected for which data with the required characteristics are available. However, this risks biasing the poverty analysis, potentially in significant ways. For example, if data on wildlife damage to crops only are available, then the MPI will not address pressing conditions affecting fisher folk, urban dwellers, and forest dwellers. Thus, in order to justify the selected ENR deprivations' inclusion in the MPI a final stage is to justify that in some way the ENR indicators included represent the most pressing conditions of the poor. Naturally, there is a logical problem, in that if appropriate data do not exist on some ENR conditions it will not be possible to include them. However, this issue must be confronted and discussed explicitly, if only to acknowledge limitations of the first generation of ENR-enhanced MPIs.

A second question that will emerge is more technical, and concerns how to incorporate a bevy of ENR indicators, each of which apply only to certain populations. For example, one might have ten ENR indicators for a particular country. Air pollution and exposure to earthquake apply everywhere, but the other eight apply only to certain regions or livelihoods or population groups. There is no data on deforestation where there are no forests. There are two measurement strategies. The first is to apply all ten indicators to all people, coding the non-applicable groups as being non-deprived, as was explained above. This is a clear solution, and has the advantage of simplicity; however, note that where extensive 'non-applicable' indicators exist, it will mechanically lower the level of measured deprivations (the deprivation scores and intensity), so a lower poverty cut-off may be required to identify as poor an equivalent population.

The second measurement strategy is to create a dimension of environmental conditions, but use different indicators for two or three groups: for example, urban, rural coastal, rural sierra, and rural plain. In each group, different environmental indictors might be used to reflect the relevant deprivations. A similar strategy has been implemented in child poverty measures in Bhutan for example (Alkire *et al.* 2016), which included a dimension 'childhood conditions' that had malnutrition for children 5 and below, child labour for children 6-14, and reproductive health issues for those 15-17.

Whichever case is used, a key question for the ENR issues are the weights on indicators, which must be fixed such that the weights reflect – across regions of the country and ENR indicators – the relative value of each deprivation. Also, the balance of weights between ENR and poverty indicators must seem justifiable and robustness tests must be applied. A potentially novel contribution is that insofar as ENR conditions affect health, it may be possible to inform the normative weighting structure by scientific evidence for example of the medical effects of different experienced hazards.

The concerns raised in this section may seem considerable, but will clarify quickly as trial ENR-enhanced MPIs are constructed and self-critically analysed, as robustness tests are performed, and as the data landscape clarifies. None are insurmountable.

6.5 Analysing ENR alongside the MPI

For ENR-related aspects that cannot be included within the MPI, it might be relevant to map the MPI according to the environmental geospatial data to identify possible correlations between geographical data (floods, droughts, soil erosion, etc.) and the level of MPI. It can help to better understand the relationships and potential correlations between environmental-poverty variables. The geo-referencing of households[12] is an opportunity to envisage spatial re-aggregations/re-allocations.

Poverty mapping has made great strides during recent years (Agola and Awange 2014; Henninger and Snel 2002; Henninger and Hammond 2002; Hyman *et al.* 2005; Watmough *et al.* 2016). New insights governing the linkages between datasets at various geographic scales (when and where it is desirable and feasible), how to use GPS data, and in general how to spatialize socioeconomic data, are provided by the DHS Spatial Analysis Reports (e.g. Burgert *et al.*, 2014).

Mapping the MPI according to environmental data could therefore offer rich analyses, especially on variables that are not captured in any household surveys. Areas where people live are of tremendous importance when assessing people's access to and use of the means of subsistence provided by ENR. Leimgruber (2004) shows, for instance, that remoteness in the sense of living far away from economic centres may result in social marginality by limiting access to work, education, and health care. As far as ENR are concerned, "most less-favourable areas are uplands, highlands, arid or semi-arid zones where low

[12] As mentioned in Brown et al. (2014), DHS has collected geographic information in most surveyed countries at the level of the cluster since the 1990s.

agricultural productivity results from a variety of constraining environmental factors including limited soil fertility, prohibitive slopes, or unfavourable temperature or hydrological conditions with economic factors such as poor infrastructure or market access. (…) Evidence across nations demonstrates that not only are the poor mainly found in rural areas where agriculture is the main source of income, but also that poverty rates are higher in areas that can be classified as marginal for agricultural production." (Pingali *et al.* 2014). There are many large-scale geo-referenced datasets available that can provide insights into these topics, such as access and distance to markets, level of human activity, remoteness, agricultural production and topography (e.g. Nelson *et al.* 2008; Jarvis *et al.* 2008; Hijmans *et al.* 2005).

7 Next steps

This paper has offered a conceptual framework for linking ENR and multidimensional poverty based on Sen's capability approach, and suggested a taxonomy of three components and nine subcomponents of ENR as a starting point to consider when building ENR-enhanced multidimensional poverty measures. Which of these components, or any additional ones, are most relevant in a specific context, should be assessed and this tentative framework adjusted and improved if it would be useful to do so.

One necessary next step beyond this paper is to create a taxonomy of potential indicators, and relevant datasets, for joint studies of MPI and ENR, and/or for combining these into an ENR-enhanced MPI. Moving to the selection of indicators, the paper articulated the distinctive requirements that are needed in order for ENR indicators to be included in MPIs, because these transparently draw upon the joint distribution of deprivations. It also introduced certain challenges, such as the different respective sampling designs of environmental and poverty data. A proposed indicator taxonomy would therefore need to establish how the ENR indicators satisfied the design criteria mentioned in this paper, and also propose ways in which the ENR data could be processed, or where necessary transformed, in order to be integrated in an MPI.

Where resources suffice, a further exercise would be to identify relevant datasets and/or propose new data collection efforts, developing appropriate methodologies and determining which of the indicators would best be integrated into the MPI and which are instead most appropriately analysed alongside the MPI. More broadly, the proposed ENR-MPI methodology could be further developed in the context of a series of technical and deliberative workshops. The development of 'global' indicators would require such an exercise with experts from a range of backgrounds. This could be complemented with technical in-country workshops to adapt the methodology to particular contexts.

Ground testing the proposals will be essential in order to move from the theoretical review to the practical implementation of an ENR-enhanced and policy relevant MPI. Therefore, it will be very fruitful to field test the proposed methodology and implement imperfect but feasible MPIs. This piloting would give rise to refining and adjusting the methodology as well as clarify data needs. On the basis of the results, one could propose a methodological manual, to be developed in collaboration with, and for the use of, the SDG indicators community both at country level and cross-nationally. We have good reasons to think that, given the increasingly strong impact of ENR-related issues on poverty, a generalized methodology that would better capture the way ENR affect the poor's livelihoods, in their multiple dimensions, will be both necessary and possible in the very near future.

Bibliography

Adger, W.N., Kelly, P.M., 1999. 'Social Vulnerability to Climate Change and the Architecture of Entitlements. Mitigation and Adaptation., *Strategies for Global Change* 4, 253–266.

Adger, N.W., 2006. Vulnerability. *Global Environmental Change*, 16, 268–281.

Adger, W.N., Winkels, A., 2014. 'Vulnerability, poverty and sustaining well-being', in Atkinson, G., Dietz, S., Neumayer, E., and Agarwala, M. (Eds.). 2014. *Handbook of sustainable development*. Edward Elgar Publishing.

Agola, N.O., Awange, J.L., 2014. *Globalized Poverty and Environment*. Springer, Berlin Heidelberg.

Akter, S., Mallick, B., 2013. 'The poverty–vulnerability–resilience nexus: Evidence from Bangladesh'. *Ecological Economics* 96, 114–124.

Alkire, S. and Foster, J., 2011. 'Counting and Multidimensional Poverty Measurement'. *Journal of Public Economics*, 95(7–8): 476–487.

Alkire, S., Foster, J., 2016. 'Dimensional and distributional contributions to multidimensional poverty'. OPHI Working Paper 100, University of Oxford.

Alkire, S., Foster, J., Seth, S., Santos, M.E., Roche, J. M., Ballon, P., 2015. *Multidimensional poverty measurement and analysis*. Oxford University Press, New York, NY.

Alkire, S., 2016. 'Towards frequent and accurate poverty data.' OPHI Research in Progress 43c, University of Oxford.

Alkire, S., Chatterjee, M., Conconi, A., Seth, S., and A. Vaz., 2014. 'Poverty in Rural and Urban Areas: Direct Comparisons Using the Global MPI 2014'. OPHI Briefing 24.

Alkire, S., Dorji, L., and T. Minten, 2016. *Child poverty in Bhutan. Insight from Multidimensional Child Poverty Index and Qualitative Interviews with Poor Children*, Bhutan National Bureau of Statistics.

Alkire, S. Robles Aguilar, G., 2015. 'Poverty maps. Mapping multidimensional poverty so policies can fight it efficiently'. OPHI Briefing 37, December 2015.

Alkire, S., Samman, E. 2014. 'Mobilising the Household Data Required to Progress toward the SDGs.' OPHI Working Paper 72.

Alkire, S, Santos, M. E., 2010. Acute Multidimensional Poverty: A New Index for Developing Countries. OPHI Working Paper 38.

Alkire, S., Santos, M. E., 2014. 'Measuring Acute Poverty in the Developing World: Robustness and Scope of the Multidimensional Poverty Index'. *World Development*, Elsevier, 59(C): 251-274.

Alkire, S., Sumner, A., 2013. 'Multidimensional Poverty and the Post-2015 MDGs'. *Development*, 56(1): 46-51.

Alkire, S., 2010. *The multidimensional Poverty Index and the Millennium Development Goals: Showing Interconnections*, November 2010. Available *here*. (consulted 25/05/2016).

Angelsen, A. (Ed.), 2011. *Measuring livelihoods and environmental dependence: methods for research and fieldwork*. Earthscan, London; Washington, DC.

Barbier, E.B., 2010. 'Poverty, development, and environment'. *Environment and Development Economics*, 15: 635–660.

Barrett, C. B. 2005. 'Rural poverty dynamics: Development policy implications'. *Agricultural Economics*, 32, 45–60.

Brouwer, R., Akter, S., Brander, L., Haque, E., 2007. *Socio-economic vulnerability and adaptation to environmental risk: a case study of climate change and flooding in Bangladesh*. Risk Analysis, 27(2): 313–326.

Brown, M.E., Grace, K., Shively, G., Johnson, K. B., and M. Carroll, 2014. 'Using satellite remote sensing and household survey data to access human health and nutrition response to environmental change'. *Population and Environment*, 36: 48-72.

Bruce, N., Perez-Padilla, R., and Albalak, R., 2000. 'Indoor air pollution in developing countries: a major environmental and public health challenge'. *Bulletin of the World Health Organization*, 78(9): 1078-1092.

Buonanno, G., Stabile, L., Morawska, L., and Russi, A., 2013. 'Children exposure assessment to ultrafine particles and black carbon: the role of transport and cooking activities'. *Atmospheric environment*, 79, 53-58.

Burgert, Clara R., and Debra Prosnitz. 2014. 'Linking DHS Household and SPA Facility Surveys: Data Considerations and Geospatial Methods'. *DHS Spatial Analysis Reports*, 10. Rockville, Maryland.

Burgert-Brucker, Clara R., Dontamsetti Trinadh, Marshall Aileen M. J., Gething, Peter W., 2016. 'Guidance for Use of The DHS Program Modeled Map Surfaces'. *DHS Spatial Analysis Reports*, 14. Rockville, Maryland, USA: ICF International.

Chambers, R. and Conway, G., 1992. 'Sustainable rural livelihoods: practical concepts for the 21st century'. *IDS Discussion Paper*, 296. Brighton, Institute of Development Studies.

Cutter, S.L., Emrich, C.T., Webb, J.J., Morath, D., 2009. *Social Vulnerability to Climate Variability Hazards: A Review of the Literature. Final report to Oxfam America* Available here. Accessed on May 29, 2016.

Dasgupta, S., Deichmann, U., Meisner, C., and Wheeler, D., 2005. 'Where is the poverty–environment nexus? Evidence from Cambodia, Lao PDR, and Vietnam'. *World Development*, 33(4): 617-638.

Dash, N. and B. H. Morrow, 2007. 'Lasting effects of Hurricane Andrew on a working-class community'. *Natural Hazards Review* 8(1): 13-21.

De Sherbinin, A., Carr, D., Cassels, S., and Jiang, L., 2007. 'Population and environment'. *Annual Review of Environment and Resources*, 32: 345–373.

De Sherbinin, A., Vanwey, L. K., Mcsweeney, K., Aggarwal, R., Barbieri, A., Henry, S., Walker, R., 2008. 'Rural household demographics, livelihoods and the environment'. *Global Environmental Change*, 18: 38–53.

DFID (Department for International Development), 1999. *Sustainable Livelihoods Guidance Sheet*, April 1999.

DFID (Department for International Development), FAO (Food and Agriculture Organization), IFAD (International Fund for Agriculture Development), UNDP (United Nations Development Program), WFP (World Food Program), 2000. *Forum on Operationalizing Participatory Ways of Applying Sustainable Livelihoods Approaches,* Proceedings, FAO and DFID, United Kingdom. Available here.

DFID (Department for International Development), EC (European Commission), UNDP (United Nations Development Programme) and World Bank. (2002). *Linking Poverty Reduction and Environmental Management – Policy Challenges and Opportunities*. Washington D.C.: World Bank.

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J.R., Arico, S., Báldi, A., Bartuska, A., Baste, I.A., Bilgin, A., Brondizio, E., Chan, K.M., Figueroa, V.E., Duraiappah, A., Fischer, M., Hill, R., Koetz, T., Leadley, P., Lyver, P., Mace, G.M., Martin-Lopez, B., Okumura, M., Pacheco, D., Pascual, U., Pérez, E.S., Reyers, B., Roth, E., Saito, O., Scholes, R.J., Sharma, N., Tallis, H., Thaman, R., Watson, R., Yahara, T., Hamid, Z.A., Akosim, C., Al-Hafedh, Y., Allahverdiyev, R., Amankwah, E., Asah, S.T., Asfaw, Z., Bartus, G., Brooks, L.A., Caillaux, J., Dalle, G., Darnaedi, D., Driver, A., Erpul, G., Escobar-Eyzaguirre, P., Failler, P., Fouda, A.M.M., Fu, B., Gundimeda, H., Hashimoto, S., Homer, F., Lavorel, S., Lichtenstein, G., Mala, W.A., Mandivenyi, W., Matczak, P., Mbizvo, C., Mehrdadi, M., Metzger, J.P., Mikissa, J.B., Moller, H., Mooney, H.A., Mumby, P., Nagendra, H., Nesshover, C., Oteng-Yeboah, A.A., Pataki, G., Roué, M., Rubis, J., Schultz, M., Smith, P., Sumaila, R., Takeuchi, K., Thomas, S., Verma, M., Yeo-Chang, Y., Zlatanova, D., 2015. 'The IPBES Conceptual Framework — connecting nature and people'. *Current Opinion in Environmental Sustainability*, 14: 1–16.

Dumenu, W.K., Obeng, E.A., 2016. 'Climate change and rural communities in Ghana: Social vulnerability, impacts, adaptations and policy implications'. *Environmental Science and Policy* 55, Part 1, 208–217.

Duraiappah, A. 1998, 'Poverty and environmental degradation: a review and analysis of the nexus', *World Development*, 26(12): 2169–2179.

EPI, 2016. *Global Metrics for the Environment. 2016 Report*. New Haven, CT: Yale University. Available *here*.

Fisher, B., Christopher, T., 2007. 'Poverty and biodiversity: Measuring the overlap of human poverty and the biodiversity hotspots'. *Ecological Economics*, 62: 93–101.

Frankenberger, T., Drinkwater, M. and Maxwell, D., 2001. 'Operationalizing household livelihood security', in FAO (ed.), *Forum on Operationalizing Participatory Ways of Applying Sustainable Livelihoods Approaches*, FAO: Rome.

Galizzi, P., Herklotz, A. (Eds.), 2008. *The role of the environment in poverty alleviation*, 1st ed. ed, People and the environment lecture series. Fordham University Press, New York.

Gallopín, G.C., 2006. 'Linkages between vulnerability, resilience, and adaptive capacity. Global Environmental Change, 16: 293–303.

Graziano, P., Rizzi, P., 2016. Vulnerability and resilience in the local systems: The case of Italian provinces'. *Science of The Total Environment* 553, 211–222.

Hein, L., Van Koppen, K., De Groot, R. S., and Van Ierland, E. C., 2006. 'Spatial scales, stakeholders and the valuation of ecosystem services'. *Ecological economics*, 57(2): 209-228.

Henninger, N., Hammond, A., 2002. 'Environmental Indicators Relevant to Poverty Reduction'. *World Bank Environment Strategy Papers*, 3.

Henninger, N., Snel, M., 2002. *Where are the poor? Experiences with the Development and Use of Poverty Maps*, WRI and UNEP/GRID-Arendal.

Hijmans, R.J., Cameron, S.E., Parra, J.L., Jones, P.G. and Jarvis, A. 2005. 'Very high resolution interpolated climate surfaces for global land areas'. *International Journal of Climatology*, 25: 1965-1978.

Houston, D., Wu, J., Ong, P., and Winer, A., 2004. 'Structural disparities of urban traffic in southern California: Implications for vehicle-related air pollution exposure in minority and high-poverty neighborhoods'. *Journal of Urban Affairs*, 26(5), 565-592.

Hsu, A. et al., 2016. 2016 *Environmental Performance Index*. New Haven, CT: Yale University. Available *here*.

Hyman, G., Larrea, C., Farrow, A., 2005. 'Methods, results and policy implications of poverty and food security mapping assessments'. *Food Policy*, 30 (5–6): 453–460.

IFAD, 2014. *The Multidimensional Poverty Assessment Tool: User's Guide. An innovative new tool for assessing, understanding and addressing rural poverty*. Rome: International Fund for Agricultural Development.

ILO, 2001. *Ambient Factors in the workplace. An ILO Code of Practice*, Geneva, International Labour Office.

IPCC, 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jarvis, A., Reuter, H.I., Nelson, A., and Guevara, E. 2008. *Hole-filled SRTM for the globe Version* 4.

Kovats, R. S., and Haines, A., 2005. 'Global climate change and health: recent findings and future steps'. *Canadian Medical Association Journal*, 172(4): 501-502.

Leimgruber, W., 2004. *Between global and local: marginality and marginal regions in the context of globalization and deregulation*. Ashgate Publishing, Farnham.

Lugo, M. A., 2007. 'Employment: A Proposal for Internationally Comparable Indicators', *Oxford Development Studies*, 35(4): 361 – 378.

Martin, R., Linstädter, A., Frank, K., Müller, B., 2016. 'Livelihood security in face of drought – assessing the vulnerability of pastoral households'. *Environmental Modelling and Software* 75, 414–423.

Masozera, M., M. Bailey, and C. Kerchner, 2007. 'Distribution of impacts of natural disasters across income groups: a case study of New Orleans'. *Ecological Economics*, 63(2-3): 299-306.

Massey, D.S., 2015. *Migration: Motivations, in: International Encyclopedia of the Social and Behavioral Sciences*. Elsevier, 452–456.

McMichael, A., 2000. 'The urban environment and health in a world of increasing globalization: issues for developing countries', *Bulletin of the World Health Organization*, 2000, 78(9).

MEA, 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.

Narayan, D. (ed.) *et al.* 2000. *Can Anyone Hear Us? Voices of the Poor Study*, Volume 1, Oxford: Oxford University Press.

Nelson *et al.* 2008. *Estimated travel time to the nearest city of 50,000 or more people in year 2000. Global Environment Monitoring Unit* – Joint Research Centre of the European Commission, Ispra Italy.

Peacock, W. G., B. H. Morrow and H. Gladwin (eds.), 2000. *Hurricane Andrew and the reshaping of Miami: Ethnicity, gender, and the socio-political ecology of disasters*. Miami, FL: Florida International University, International Hurricane Center.

Picou, J.S., Nicholls, K., Guski, R., 2015. 'Environmental Stress and Health', in: *International Encyclopedia of the Social and Behavioral Sciences*. Elsevier, 804–808.

Pingali, P., Schneider, K., Zurek, M., 2014. 'Poverty, Agriculture and the Environment: The Case of Sub-Saharan Africa', in: von Braun, J., Gatzweiler, F.W. (Eds.), *Marginality*. Springer Netherlands, Dordrecht, 151–168.

Reid, H., and Huq, S., 2005. 'Climate change-biodiversity and livelihood impacts', in Robledo, C., Kanninen, M., Pedroni, L., *Tropical forests and adaptation to climate change*, CIFOR, 57-70.

Rivas, I., Kumar, P., and Hagen-Zanker, A., 2017. 'Exposure to air pollutants during commuting in London: are there inequalities among different socio-economic groups?' *Environment International*, 101: 143-157.

Robeyns, I., 2006. 'The capability approach in practice'. *Journal of Political Philosophy*, 14(3): 351-376.

Scherr, S.J., 2000. 'A downward spiral? Research evidence on the relationship between poverty and natural resource degradation'. *Food Policy*, 25: 479–498.

Schleicher, J., Schaafsma, M., Burgess, N., Sandbook, C., Danks, F., Cowie, C., and Vira, B (in review). 'Poorer without it? The Missing Role of the Natural Enviornment for Wellbeing and Poverty'.

Scoones, I., 1998. *Sustainable rural livelihoods: a framework for analysis*.

Sen, A. K., 1992. *Inequality Re-examined*. Oxford University Press.

Sen, A. K., 1993. 'Capability and Well-Being', in M. C. Nussbaum and A. Sen (eds.) *The Quality of Life*. Oxford University Press, 9–29.

Sen, B., 2003. 'Drivers of escape and descent: changing household fortunes in rural Bangladesh'. *World Development*, 31: 513–534.

Shah, A., 2009. 'Natural resources and chronic poverty', *Chronic Poverty Research Centre Working Paper*, 152.

Shively, G., Sununtnasuk, C. and Brown, M., 2015. 'Environmental variability and child growth in Nepal'. *Health and Place*, 35: 37-51.

Shyamsundar, P., 2002. *Poverty-Environment Indicators*. World Bank Environmental Economic Series, 84.

Sjaastad, E., Angelsen, A., Vedeld, P., Bojö, J., 2005. 'What is environmental income?' *Ecological Economics*, 55: 37–46.

Smit, B., and Wandel, J. 2006. 'Adaptation, adaptive capacity and vulnerability'. *Global Environmental Change*, 16(3): 282-292.

UNDP (United Nations Development Programme), UNEP (United Nations Environment Programme), IIED (International Institute for Environment and Development), IUCN (International Union for the Conservation of Nature), WRI (World Resources Institute), 2005. *Investing in Environmental Wealth for Poverty Reduction*. New York: United Nations Development Programme.

UNDP (Ed.), 2011. *Sustainability and equity: a better future for all*. Houndmills: Palgrave Macmillan.

UN General Assembly, 2015. *Transforming our world: the 2030 Agenda for Sustainable Development*. New York: United Nations.

UNICEF, 2015. *Unless we act now. The impact of climate change on children*. UNICEF, November 2015.

UNICEF, 2016. *Clear the air for children*, UNICEF, October 2016.

UNSD, 2016. *Framework for the Development of Environment Statistics (FDES 2013). Final official edited version*. UNSD, June 2016.

Veit, P.G., Mascarenhas, A., Ampadu-Agyei, O., 1995. *Lessons from the Ground Up: African Development that Works*. World Resources Institute, Washington.

von Braun, J.V., 2013. *Marginality: addressing the nexus of poverty, exclusion and ecology*. Springer, New York.

Watmough, G.R., Atkinson, P.M., Saikia, A., Hutton, C.W., 2016. 'Understanding the Evidence Base for Poverty–Environment Relationships using Remotely Sensed Satellite Data: An Example from Assam, India'. *World Development*, 78: 188–203.

White, T.A., Runge, C.F., 1994. 'Common property and collective action: lessons from cooperative watershed management in Haiti'. *Economic Development and Cultural Change*, 43(1): 1–41.

WHO, 1993. *A Report of a World Health Organisation Consultation on Health and Environment in Preparation for 2nd European Conference on Environment and Health, Helsinki 20–22* June 1994. Sofia, Bulgaria: World Health Organization.

World Bank (Ed.), 2007. *Poverty and the environment: understanding linkages at the household level, Environment and development*. The World Bank, Washington, DC.

Annex: ENR-related DHS and MICS variables

DHS Variables

Household	
HV024	**Region of residence in which the household resides.**
HV025	HV025 Type of place of residence where the household resides as either urban or rural.
HV201	Major source of drinking water for members of the household. Individual codes are country-specific, but the major categories are standard.
HV204	**Time taken to get to the water source for drinking water.**
HV213	**Main material of the floor. Individual codes are country-specific, but the major categories are standard.**
HV214	**Main material of the walls. Individual codes are country-specific, but the major categories are standard.**
HV215	**Main material of the roof. Individual codes are country-specific, but the major categories are standard.**
HV226	**Type of cooking fuel.**
HV235	Location of source for water.
HV236	Person fetching water
HV237	Anything done to water to make safe to drink
HV241	Food cooked in the house, in separate building, or outdoors
HV242	**Household has separate room used as kitchen**
HV244	**Own land usable for agriculture**
HV245	Hectares for agricultural land
HV246	Livestock, herds or farm animals
HV252	**Frequency household members smoke inside the house**
HV253	Has dwelling been sprayed against mosquitoes in last 12 months
RECHML	
V705	Standardized partner's occupation groups. Agricultural categories also include fishermen, foresters and hunters and are not the basis for selection of agricultural/non-agricultural workers for the variables that follow.
V716	Respondent's occupation as collected in the country. Codes are country-specific.

V717	Standardized respondent's occupation groups. Agricultural categories also include fishermen, foresters and hunters and are not the basis for selection of agricultural/non-agricultural workers.
Woman	
V024	Region of residence
V025	Type of place of residence
V467D	Distance to Health Facility
V716	Respondent's occupation as collected in the country. Codes are country-specific.
V717	Standardized respondent's occupation groups. Agricultural categories also include fishermen, foresters and hunters and are not the basis for selection of agricultural/nonagricultural workers.
V740	Whether the respondent works on her own land, family land, rented land or on someone else's land. This question is no longer part of the DHS VI core questionnaire, but the variable is kept in the DHS VI recode. BASE: Women who are currently working or who have worked in the last 12 months, andwho work or worked in agriculture (V716 = country-specific agricultural category).
V745b	**Owns land alone or jointly**
(W122A)	Possessions: land
(W123A)	Control over the possessions: land
(W131)	Member of an association
Man	
MV716	Respondent's occupation as collected in the country. Codes are country-specific.
MV717	Standardized respondent's occupation groups; agricultural categories also include fishermen, foresters and hunters and are not the basis for selection of agricultural/non-agricultural workers.
MV740	Whether the respondent works on his own land, family land, rented land, or on someone else's land.
MV745b	Owns land alone or jointly.
Child	
V103	Childhood place of residence is classified into city, town and countryside as reported by the respondent.