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Essential Variables help to focus Sustainable Development Goals monitoring

Belinda Reyers[1,2,3], Mark Stafford-Smith[4,2], Karl-Heinz Erb[5], Robert J Scholes[6] and Odirilwe Selomane[3,7]

The imperative to measure progress towards Sustainable Development Goals (SDGs) has resulted in a proliferation of targets and indicators fed by an ever-expanding set of observations. This proliferation undermines one principal purpose of the SDGs: to provide a framework for coordinated action across policy domains. Systems approaches to defining Essential Variables have focused monitoring of climate, biodiversity and oceans and offer opportunities to coordinate SDG monitoring. We propose four criteria and a process to identify Essential SDG Variables (ESDGVs), which will highlight interactions and gaps in current monitoring. The ESDGV criteria suggest a research agenda to: develop and test interdisciplinary system models; test transformations theory for sustainable development; analyse policy interactions; and formulate models to support further refinements of ESDGVs and SDG monitoring.

Addresses
[1] Stockholm Resilience Centre, Stockholm University, SE-106 91 Stockholm, Sweden
[2] Future Earth Science Committee, FutureEarth.org
[3] Department of Conservation Ecology and Entomology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa
[4] CSIRO Land and Water, P.O. Box 1700, Canberra, ACT 2601, Australia
[5] Institute of Social Ecology, Vienna, Alpen-Adria Universitaet Klagenfurt-Vienna-Graz, Schottenfeldgasse 29, A-1070 Vienna, Austria
[6] Global Change and Sustainability Research Institute, Wits, 2050, South Africa
[7] Natural Resources and the Environment, Council for Scientific and Industrial Research, P.O. Box 320, Stellenbosch 7599, South Africa

Corresponding author: Reyers, Belinda (belinda.reyers@su.se)

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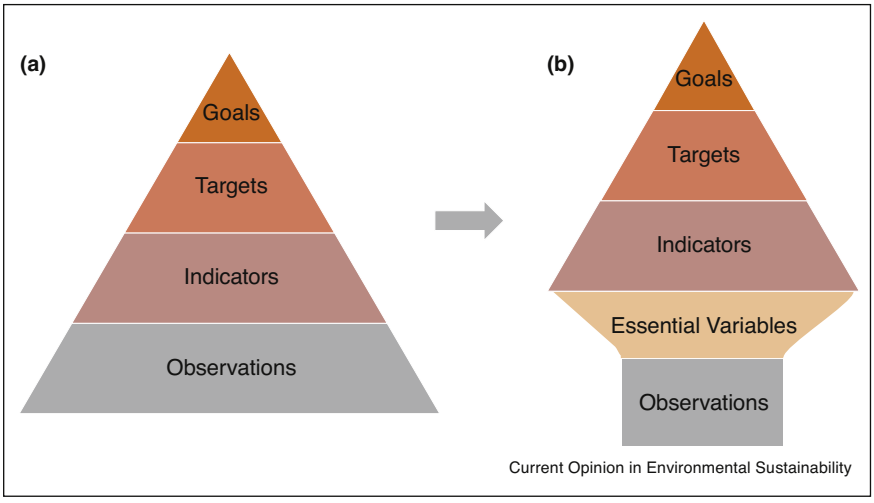
Challenging the proliferation logic of SDG monitoring

The world has recently agreed to 17 Sustainable Development Goals (SDGs), supported by 169 targets, in turn fed by an initial set of 230 indicators [1], each one of which relies on existing and new multiple data streams for its development (Figure 1a). Under this current proliferation logic, the process of developing an SDG monitoring system inexorably results in an ever-expanding set of observations which are certain to prove a burden for nation states [2,3]. The monitoring burden driven by this proliferation logic also increases the likelihood of uncoordinated monitoring by separate agencies, losing coherence as a result [4•].

There are over seven hundred multi-lateral environment agreements [5], and many more addressing social and economic development [6], all with their attendant monitoring schemes. One of the principal purposes of the SDGs [7] is to provide a framework within which action towards these various agreements can be coordinated [6,8•,9]. Thus, one might argue, the over-riding priority for SDG-specific monitoring systems should be to inform this process of coordination [4•,10]. Instead of a proliferation logic that says "The SDGs encompass many areas of activity and they all need to be monitored and reported on under the SDGs process", the logic could then become one of coordination: "The SDGs monitoring process should focus on ensuring coordination and fill important gaps among the many areas of activity that have their own individual monitoring processes".

In moving towards a more coordinated logic for SDG monitoring, advances in systems theory (*e.g.* [11–14]) offer potential ways to structure such a monitoring system. One systems approach is Essential Variables (EVs; Table 1) which has arisen to prioritise and coordinate the monitoring of climate [15••], biodiversity [16••] and oceans [17••], and which is an area of active research and application in other communities (see next section). EVs are the minimum set of variables required to characterise change in a system. The purpose of this contribution is to review the potential for the EV approach to limit the tendency towards proliferation in monitoring for the SDGs and refocus effort on a coordinated system. We also identify the transdisciplinary research agenda that would be required to support such a development.

Figure 1



The introduction of Essential Variables (EV) as a layer between primary observations and indicators can transform the shape of monitoring systems from (a) an ever-broadening pyramid to (b) a more streamlined form. In (b) a limited number of EVs, directing a targeted set of repeatable and universal observations, underpin a changing superstructure of policy-relevant indicators, targets and goals. The EV layer insulates the observation levels from the changing policy priorities, and makes the policy indicators independent of the observational platform. It further harnesses systems understanding so that a single EV capturing a key process or structure can potentially contribute to multiple indicators, while similarly 2 or more EVs can direct and use the same primary observations, thus potentially enabling a reduction in the numbers of observations needed to deliver those indicators.

The Essential Variables approach to monitoring complex systems

The concept of Essential Variables was first used by the Global Climate Observing System (GCOS) in the 1990s. It defined essential climate variables (ECVs) as "physical, chemical, or biological variables or a group of linked variables that critically contributes to the characterization of Earth's climate" (GCOS 2010). The ECVs were proposed as a response to the need for a more coordinated approach to global climate observations [15••,18]. Criteria to identify ECVs included relevance in characterizing the climate system and its changes, feasibility of observing and deriving the variables, and cost effectiveness. The ECVs have been widely endorsed in both science and policy circles. The ECV process, guided by regular reviews and updates, continues to evolve in response to changing priorities, needs, new knowledge and innovation [15••].

Ocean scientists adopted a similar approach under the Framework for Ocean Observing, leading in 2010 to community-defined Essential Ocean Variables (EOVs) [19]. The EOVs process included the criterion of the 'readiness level' of the observations, allowing the inclusion of new observation types in an iterative way with regular feedback loops (*e.g.* [16••]). Similar processes have since been followed within the biodiversity observation community, leading to the Essential Biodiversity Variables (EBVs). These are defined as "essential dimensions of biodiversity change" [16,20–23]. The EBV approach further clarifies that Essential Variables "lie between primary observations and indicators" [24]. This level of

Table 1

List of acronyms describing Essential Variable types including their status of development

Acronym	Description	Status
EV	Essential Variables	
ECV	Essential Climate Variables	Existing
EBV	Essential Biodiversity Variables	Existing
EOV	Essential Ocean Variables	Existing
ESocV	Essential Social Variables	Some existing, but not described as such
ExxV	Essential Variables for missing domains	Proposed for domains not yet thinking in this way that may need collecting under SDGs
ESDGV	Essential Sustainable Development Goal Variables	Proposed entire set of EVs for the SDGs
core ESDGV	Core Essential Sustainable Development Goal Variables	Proposed core set of EVs not collected within sectors, focused on sectoral interactions, transformations and in the social-ecological interface.