Ranking of effectiveness of ES/NC based measures as valued in scientific literature

Stefan Schmidt, Ralf Seppelt, Martin Volk
Helmholtz Centre for Environmental Research – UFZ

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Introduction

This milestone aims at ranking the effectiveness and efficiency of ecosystem services/natural capital (ES/NC) based measures. It is an overview of which indicator on effectiveness and efficiency exist in major ES databases and represents the first results of the analysis. The milestone should be seen as a discussion paper that allows other OPERAs partners, e.g. exemplars, to participate in the effectiveness and efficiency examination. The target is to proceed under consideration of the critic, wishes and ideas from other partners to ensure a provision of project relevant information that is later one published in the Deliverable 2.2 (November 2014) - *Report on standardized metrics/indicators for monitoring the efficiency of ES/NC based measures*.

The importance of the term *effectiveness* is gaining widespread recognition (EU 2013, Nakhooda et al. 2013, Oxfam 2012), although considerable confusion exists on how to define (ISO 9000:2005, ISO 9241-11) and measure effectiveness of ES/NC studies (Laurans et al. 2013, Zscheischler et al. 2014). Recent investigations show that due to a paucity of papers that describe, through a case study, indicators that have an influence on effectiveness and efficiency too little progress has been made in the last 20 years (Laurans et al. 2013, Lautenbach et al. 2014). Nevertheless, agreements on a set of indicators for assessing the effectiveness of selected aspects of implementation in specific ecosystems exists, for instance the Ramsar Convention indicators of effectiveness for conservation or integrative management plans in wetlands (Ramsar 2002).

The determination of what is effective is strongly context specific and is investigated by a manifold set of indicators in the literature (Sprinz 2000, Phillips et al. 2009, Martin-Lopez et al. 2013, Ruckelshaus et al. 2013, Laurens et al. 2013). In Sprinz et al. (2000) for instance effectiveness of international environmental regimes in terms of environmental problems are examined along the dimension of use of policy instruments (environmental threshold regulations) represented by the absence of exceeding critical loads in the case of trans-boundary acidification. In contrast in Backstad et al. (2013) ES tools are compared on the basis of five criteria, such as time efforts needed to complete an ES assessment. In this milestone report we defined *effectiveness* as *the accuracy and completeness (quality) with which an ES study or project achieved an objective*. The efforts to achieve the objective are not considered. *Efficiency, however, determines the relationships between results achieved (outputs) and resources used (inputs), thus, defines efforts and the economic feasibility.* Both strongly depending on the objective, i.e. only after the definition of the target it can be assessed what is effective and efficient. Objectives in ES research can be very divers, e.g. validation and comparison of new cost and time saving ES tools (Villa et al. in press, Bagstad et al. 2013) or policy advice for land use interventions and optimization of ES provisioning (van Wilgen et al. 1998, 2008) etc.

For this report we reviewed recent literature on *effectiveness* and *efficiency* and explored major ES databases dealing with globally distributed ES studies and projects. We extracted *five essential objectives* that determine effectiveness and efficiency. According to those objectives, we identified indicators based on the frequency of database entities and analyzed them in more detail in line with study/project entries.

Method

A clearly stated objective limits the frame within effectiveness and efficiency analysis can be conducted (Ruckelshaus et al. 2013, Vogel 2012).

For our analysis we identified five major objectives that we used to group indicators of effectiveness and efficiency:

i) *costs*: refer to the use of data, experts, tools and methods to reach the targets of the study or project based on market prices (Nakhooda et al. 2013), e.g. funding for the study

ii) *time*: refers to the temporal requirements to achieve the objectives (Whitlock et al. 2009), e.g. study duration or periodicity of the assessment, if repeated

iii) *methods*: represents the study design and complexity with focus on which and how tools, activities and data sources are used (Martin-Lopez et al. 2013, Backstad et al. 2013), e.g. soil sample campaign for carbon measurement to estimate carbon sequestration

iv) *people involved*: includes the expertise, number of persons and stakeholder that were involved in the study or project (Whitlock et al. 2009), e.g. background and number of people considered for the assessment or capacity building needs identified during the assessment

v) *impact*: refer to the uptake in decision making processes or environmental changes resulting from a study or project (Laurens et al. 2013, Carvill et al. 2012, Oxfam 2012), e.g. changes in legislation issues or trees planted. Here we also included background information on local conditions in the investigation area to respect local peculiarities that may lead to implementations of study/project findings, e.g. site descriptions that contain drivers and pressures in countries or biomes of interest.

To estimate the effort for ES investigations beside costs, time and people involved also the methods need to be examined. Within the integrative framework of the ES concept methods from a big variety of scientific disciplines are used so that only the information whether it is an ecological or economic study (e.g. monetarization of ES) helps to structure the studies for a better comparability in terms of effectiveness and efficiency. Indirect Indicators are considered only insofar direct once cannot be found.

In the second step of this review we screened major databases dealing with global distributed ES case studies or projects and analyzed them on the basis of the five objective groups. We extracted 29 indicators that can be used to estimate effectiveness and efficiency (Fig. 1, Tab. 1 sm). In the last step we took a closer look at the effectiveness and efficiency indicator and analyzed the number of entries and case studies.

Results

Our Meta-analysis shows that major databases dealing with globally distributed ES case studies can give only limited insights to estimate effectiveness and efficiency. This is not surprising due to the fact that the purposes of the databases are very heterogenic and none of them was created to

appraise effectiveness or efficiency. It is striking, however, that most of the indicators (57%) representing methodological aspects of the ES studies. Indicators for the estimation of the impact appear second most (20%), but the majority cannot be used. For instance the database of the review from Goldman et al. (2008) features the most indicators on impact with 47 criteria, but less than the half of all datasets have entries for more than 5 indicators. Indicators that imply background information of local conditions and drivers occur quite often, but are difficult to interpret as effectiveness and efficiency means because of high thematic variety and missing information of former mentioned indicators. Indicators on expertise, capacity building and people involved in the study or project are very rare. Also not surprisingly, but a big obstacle for effectiveness and efficiency appraisals is the low number of indicators on costs and time issues.

The numerous amounts of indicators for methods can be attributed to the high diversity of different types and topics, ranging from information on data input over set-up configuration to specific recommendations given for biophysical and socio-economic approaches. Mostly indicators for economic valuation are represented. This goes hand in hand with the increasing popularity of monetary valuation in ES research (TEEB[1], WAVES[2]; SEEA[3], de Groot et al. 2012) and the long, continuing discussions about economic valuation as the key tool for a more effective mainstreaming of biodiversity and ES (COP 2010, Heal 2000). Second mostly are indicators of the experimental set-up, an aggregation of entities that consists of input data requirements, indicators and metrics used as well as general descriptions of method and tool characteristics. A quite lower number of indicators allow conclusions on specific methods, tools and mechanisms that led to on-the-ground activities and describe activities applied to achieve final goals, e.g. specific recommendation on easements or major institutional, legal tools. Also only a few information of policy analysis that were performed can be derived from ES databases, in other words, whether the project assess what was needed politically/legally in order to be able to institute project actions.

[1] TEEB: The Economics of Ecosystems and Biodiversity http://www.teebweb.org/
[2] WAVES: Wealth Accounting and the Valuation of Ecosystem Services http://www.wavespartnership.org/en
[3] SEEA: System of Environmental-Economic Accounting https://unstats.un.org/unsd/envaccounting/seea.asp

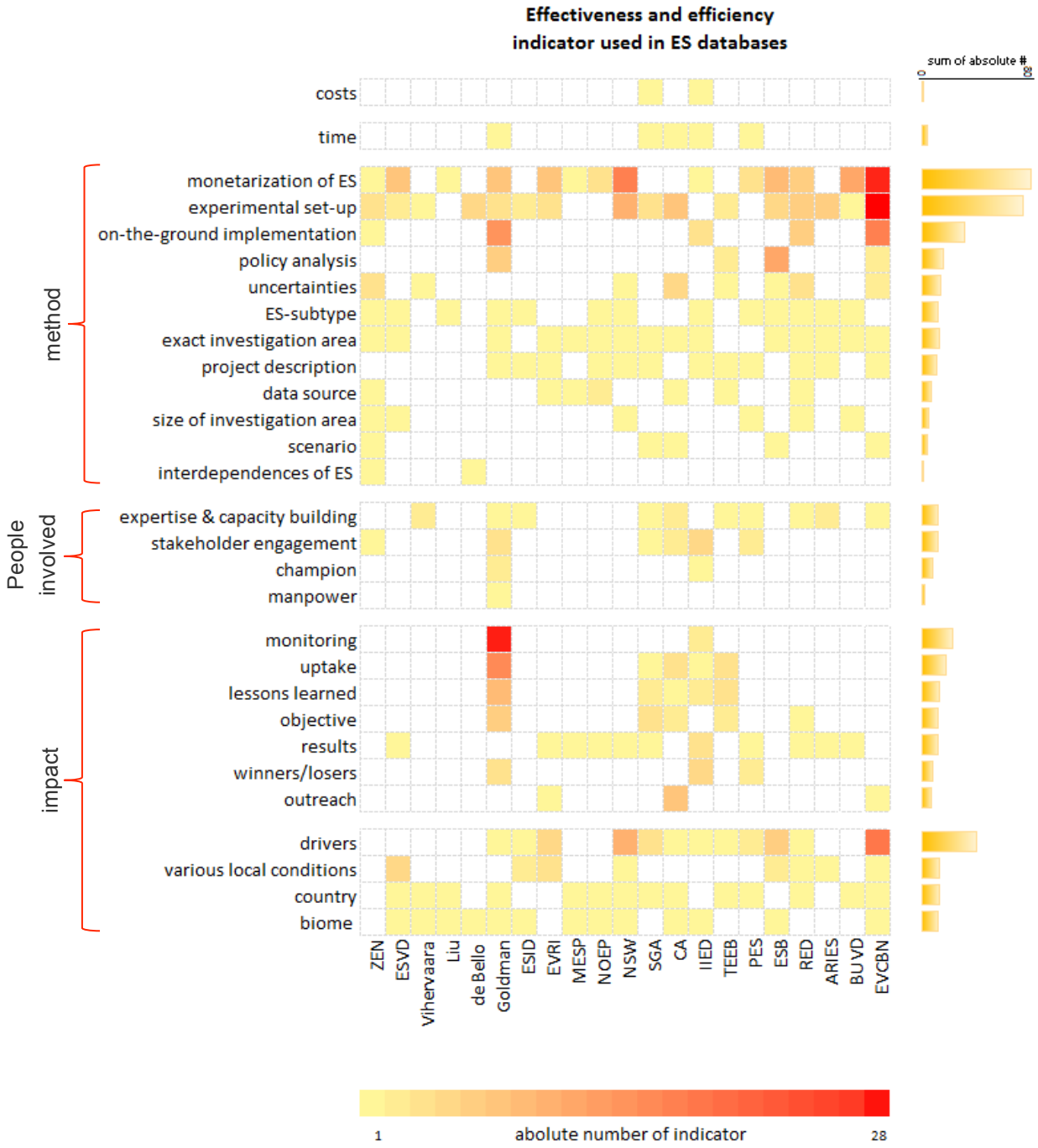

Fig.1: Identification of 29 effectiveness indicators based on 21 global ES databases. The color of the rectangles represents the frequency of effectiveness and efficiency indicators per database. The bar plots (right side) show the summation of indicators across the ES databases (see also Fig. 2 sm).

The documentation of uncertainties is mostly neglected (13 out of 21 databases) and only in 2 databases more detailed information on qualitatively and quantitatively verification of results is available. This underlines the findings from Seppelt et al. (2011) and highlights again the importance to report on validity and robustness of scientific results in the face of uncertainties to ensure reliability and relevance for different user groups.

Similarly to Laurans et al. 2013 we can summarize that too less information is available on how ES case studies had an impact in management processes or decisions as well as monitoring of study induced environmental changes. However, in a few studies we see that

i) obviously those mandated by governments and/or intergovernmental processes are generally more closely aligned with the needs of decision makers, and thus have a kind of „receiving environment" for the findings (IPBES 2013);

ii) studies and projects that identified and integrated champions in the examination show a higher uptake, i.e. experts that promotes and stand up for scientific results in policy and law making;

iii) policy analysis as a part of the ES study helps to find important entry points for the linkages of scientific findings with management structures and processes, but doesn't guarantee the implementation in decision making processes;

iv) the policy and advice generation process in a policy relevant ES case study is the most time consuming is, i.e. create user-friendly indicators, metrics and visualizations, develop guidelines tailored to the audience, identify champions, assist in applying indicator and guidelines etc.

Moreover, a low number of effectiveness and efficiency indicators on expertise, capacity building during the ES study/project and as an action taken by the study/project to build capacity as well as stakeholder engagement and manpower allows only conclusion for a subset of studies. The proficiency, capability and manpower of a research team strongly affect time and cost issues in a study or project. When capacity-building is integrated into the study/project process it can broaden and enhance participation, as well as leading to development of capacity to perform assessments on an ongoing basis (IPBES 2013). Furthermore helps the engagement of stakeholders at all stages in an assessment process to ensure the credibility, relevance and legitimacy of a study/project, and increases the extent to which findings are reflected in decision making. Recent studies have indicated that stakeholder values are the key to structured policy making with public involvement (Gregory et al. 2001, Gregory 2000). In real terms, Lorenzoni et al. (2000) found for a case study in East Anglia that indicators that had been designed to meet the practical needs of stakeholders worked best.

Data on how well and how much costs and time are spend for an ES study/project are least compiled in ES databases. At the moment there is only one database dealing with the implementation of payments for watershed markets (IIED) that provides information on time issues (project maturity) as well as funding and partly on what the money is used for in 69 projects. Cost and time requirements are central criteria to estimate effectiveness and efficiency, they limit both the investigation scope and methods (Bagstad et al 2013), they determine boundaries for the consolidation and integration of experts and stakeholder (IPBES 2013), therefore affect the quality of the findings. Based on a comparison of 17 ES tools Bagstad et al. (2013) showed that cost and time requirements to run quantitative ES models remain too high to be used in widespread decision making, in contrast to low-cost screening tools that should be more used for scoping due to the risk of oversimplification of environmental complexities.

Summary

Major databases of globally distributed ES examinations capturing almost 12.000 studies and projects. Unfortunately, *none of these was created to investigate effectiveness and efficiency in ES research*. Therefore, databases can give only limited insights into the estimation of effectiveness and efficiency of ES studies. Nevertheless, certain indicators that cover parts of an effectiveness and efficiency analysis can be identified. We explored 21 global ES databases and discovered 29 indicators based on their frequency of use as database entities (Fig. 1) as well as study/project entries. We found a highly diverse set of indicators spread over the different databases and summarized them in five groups. Effectiveness as well as efficiency are strongly context specific and need to determine for a specific objective. Our five groups refer to effectiveness and efficiency objectives and consist of i) costs and ii) time requirements, iii) methodological design and complexity, iv) expertise, stakeholder engagement and number of people involved as well as v) impact on decision making and environmental changes. Most effectiveness and efficiency indicators could be identified for iii) and v). However, due to a missing consistency and high thematic heterogeneity within the indicators groups generalizing conclusions can be made only partially. Most indicators found refer to economic valuation of ES and highlight the continually prevailing position of monetary valuation in ES research. For economic valuation methods effectiveness and efficiency appraisals are feasible. Indicators for the estimation of v) are numerous in the databases, but mostly study/project entries are missing. Despite the high number of criteria to estimate local background information that might be important for the implementation of the scientific results in practice, it is not feasible to appraise the v) due to missing information on how findings were interlinked with management structures and processes or study/project induced changes in environment can be monitored. However, data can be found which allow qualitative statements without raising the claim to stand up to quantitative scrutiny. This regards both v) affecting criteria and indicators on i) and ii) effectiveness and efficiency, which are documented by various criteria in a database focusing on payment for watershed markets (IIED). Also from case to case conclusions maybe drawn on iv) that spread over on up to twelve databases (Fig. 1). For a more in-depth analysis of effectiveness and efficiency additional information is required, which can only be collected via interviews with the study authors or project coordinators. The here identified effectiveness and efficiency indicators can thereby be used as a guideline.

In the next steps of the analysis database-crossing case studies with most indicators for effectiveness and efficiency will be identified. Based on the set of indicators of this milestone report the most important indicator will be completed and discussed in terms of the suitability of metrics for standardized monitoring of effectiveness and efficiency. In addition, recommendations are made which indicators for appraising effectiveness and efficiency must be included more frequently in future. Findings may help on how to structure the study design of exemplars and the OPERAs Resource Hub more effective and efficient.

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Supplemental Material

Tab.1: Explanation of effectiveness and efficiency indicator used in major global ES databases. The column "Examples from databases" show only a subset of indicators that were actually considered in this analysis.

Indicator name	Explanation	Examples from databases
costs	The use of experts, tools and methods to reach the targets of the study or project based on market prices.	funding involved
time	Temporal requirements to achieve the objectives of the study or project.	project length; year assessment started/finished; periodicity of assessment; if repeated, how frequently, period assessed
monetarization of ES	Indicator that describe the effort, i.e. use of economic valuation method to appraise ES in monetary units.	type of monetary valuation methods; values; valuation years; links valuation physical impact
experimental set-up	Aggregation of different indicators that describe the effort (complexity) and tools to measure ES.	tools and approach used; input required; indicators/units used
on-the-ground implementation	Specific activities, mechanism and tools that were used to enable implementation in practice.	specific recommendations; specific activities to achieve the goals (financial instruments, easement used, institutional/legal tools)
policy analysis	Indicator that describe political/legal needs in order to be able to institute project actions.	Was a policy analysis done for the project? Use of policy analysis? Politically/legally needs in order to institute project actions
uncertainties	Represents the accuracy of the findings.	general uncertainty; reviewed; validated; quality of results
ES-subtype	Indirect effectiveness and efficiency indicator on which ES subtypes are investigated. Can be used to structure ES studies/projects and estimate the effort of the analysis.	food: beef, fish; extreme events: flood prevention, storm protection etc.
exact investigation area	Indirect effectiveness and efficiency indicator on which area is investigated with which spatial resolution.	Location name; project ecoregion; Specific geographic locations of application; Receiving Environment
project description	General description on indicators for methods used as well as drivers, pressures and general background information on local conditions.	Abstract and project description
data source	Indirect effectiveness and efficiency indicator on which input data is used to estimate the effort and completeness of the ES examination (under consideration of processing and output).	primary; secondary data; references
size of investigation area	Indirect effectiveness and efficiency indicator on how big the area is that was investigated by the study/project. The indicator can be used to ensure the comparability of studies.	service area in sqkm
scenario	Indirect effectiveness and efficiency indicator on which kind of scenarios are conducted. Can be understood as an indicator for the on-the-ground implementation (see above; Reed et al. 2013) or as a further indication to estimate efforts of the examination.	Scenario analysis; Tools and approaches used in the assessment

interdependences of ES	Indirect effectiveness and efficiency indicator that represents whether trade-offs or synergies between different ES are considered. It indicates the accuracy and efficiency.	ES in isolation examined; combination of traits
expertise & capacity building	The background and know-how of people involved in a study affect the proceeding of the study, thus, the efficiency (Reed et al. 2013).	Research institute/group; organization; Capacity building needs identified during the assessment; How have gaps in capacity been communicated to the different stakeholders
stakeholder engagement	Stakeholder engagement help to ensure the credibility, relevance and legitimacy of a study/project, and increases the extent to which findings are reflected in decision making (Gregory et al. 2001, Gregory 2000).	Are stakeholder engaged? Does the study try to engage the community? If yes, using what mechanisms? How do they communicate project goals?
champion	Experts that link science and policy to implement scientific results in decision making processes.	Project implementation (In order to achieve project goals/targets what are the major conservation actions/on the ground activities occurring in the project area (Who is implementing these activities)?); broker involved; facilitator
manpower	Number of experts that were involved in the study/project	The number of people directly involved in the assessment process
monitoring	Systematic measurement or observing of processes and indicator resulting from study/project findings.	Compliance and/or performance monitoring; indicators; What is being monitored? How is it being monitored? In how many locations is the monitoring occurring? With what frequency? When did this start? Who (what organization) is collecting data? Who analyzes data?
uptake	Implementation of study/project findings in decision making, society in general or environmental changes.	interventions and response to the key findings of the study/project; policy impact; legislation issues; capacity building by the assessment; Number of seedlings planted, Number of acres restored; Change in flood risk
lessons learned	Consequences and take home message of the study/project without necessarily being implemented in practice. May include indications on how to make ES examination more effective and efficient in future.	Consequences; challenges and lessons learned; What were the key challenges in creating the project? The project process?
objective	Effectiveness and efficiency can only be analyzed relatively to the objective, i.e. desired aim and achieved goal (result) of the study/project.	purpose and objectives; ecosystem service; habitat; species; socio-economic targets; mandate for the assessment
results	Effectiveness and efficiency can only be analyzed relatively to the objective, i.e. desired aim and achieved goal (result) of the study/project.	key results of the studies/projects
winners/losers	Indirect effectiveness and efficiency indicator that identifies winner and loser. Link study/project results to people that are affected is crucial to increase relevance for policy making (Paavola et al. 2013).	Buyer/Investor; seller; stakeholder (supply, demand, facilitator, intermediary)

outreach	Indirect effectiveness and efficiency indicator on multiple ways of communicating research results not only through publishing in research outlets but also through broadcasting documentaries etc. (Reed et al. 2013)	assessment outputs: website, report, communication material, journal publication, training materials
drivers	Indirect effectiveness and efficiency indicator on which driver cause the purpose of the study. The level of intensity may affect the level of uptake.	What are the major threats/main threats to the project area? Extent of Environmental Change; Drivers of change / Driver of Ecosystem Change; What was the problem?
various local conditions	Indirect effectiveness and efficiency indicator on which driver and local structures and processes cause the purpose of the study. The local conditions may affect the level of uptake.	background information of local conditions and description why indicators is important for the region; protected area; income group; pop density; World Bank group;
country	Indirect effectiveness and efficiency indicator that represents the political division in which the study/project took place.	Country or countries covered; Site Description
biome	Indirect effectiveness and efficiency indicator that represents the biophysical area in which the study/project took place.	Biome; System; Ecosystem

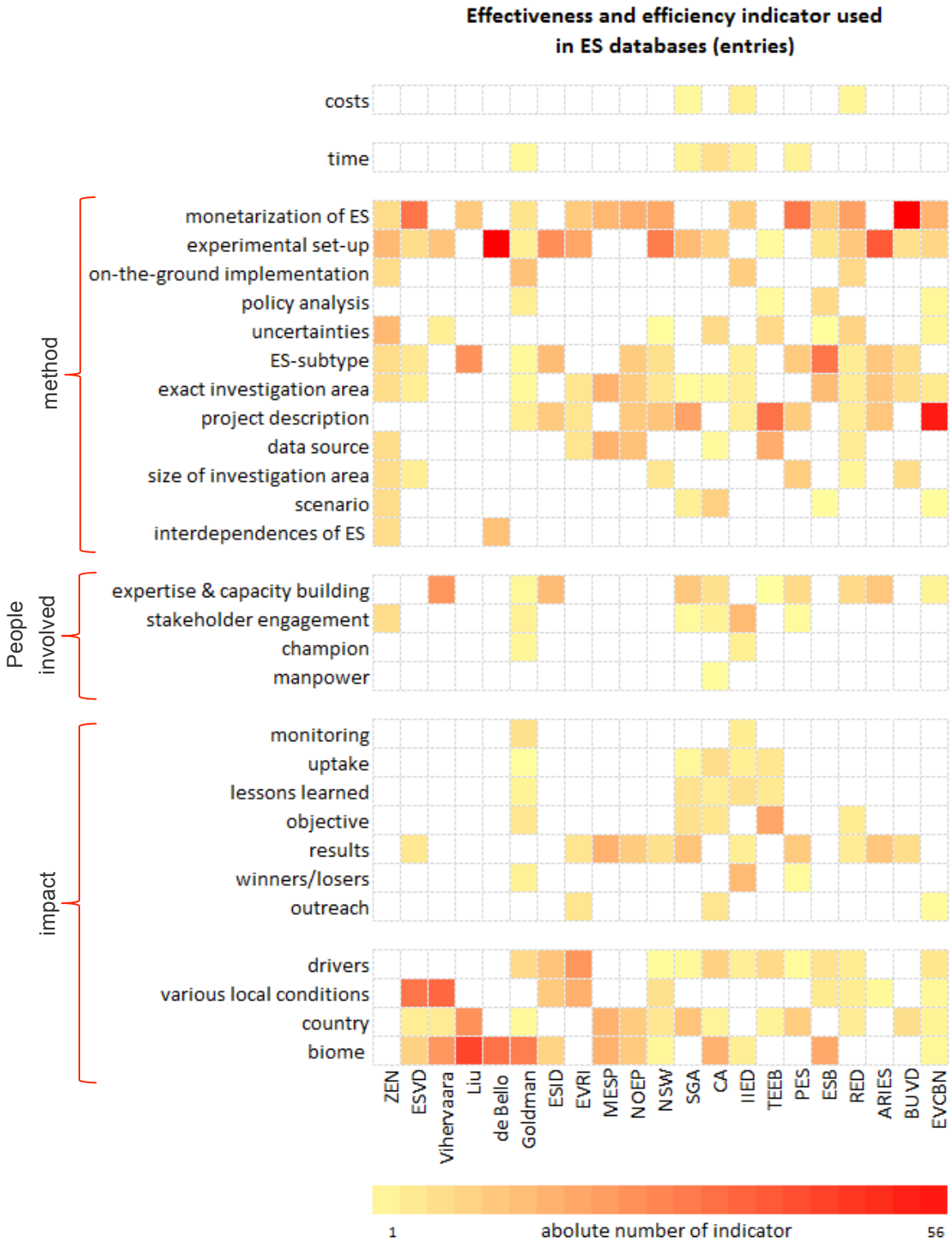

Fig. 2: Identification of 29 effectiveness indicators based on 21 global ES databases. The color of the rectangles represents the percentage of entries per database and effectiveness and efficiency indicators. In relation to the Fig. 1 that shows the absolute frequency of effectiveness and efficiency indicators, here the amount of actual information contained in the effectiveness and efficiency indicators is illustrated.