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Current Opinion in Environmental Sustainability

The Mexican National Biodiversity and Ecosystem Degradation Monitoring System

Nashieli Garcia-Alaniz[1], Miguel Equihua[2], Octavio Pérez-Maqueo[2], Julián Equihua Benítez[1], Pedro Maeda[1], Fernando Pardo Urrutia[1], José J Flores Martínez[3], Sergio A Villela Gaytán[4] and Michael Schmidt[1]

The UN sustainable development goals urge to achieve sustainable development in its economic, social and environmental dimensions. This international agenda advocates sustainable use of ecosystems and arresting and reversing land degradation and biodiversity loss. The lack of relevant, standardized and up-to-date data to monitor ecosystem change challenges to achieve this. Thus, an integrated, comprehensive resource-efficient approach is crucial to monitor ecosystems change. We introduce the recently initiated Mexican National Biodiversity and Ecosystem Degradation Monitoring System and examine three essential components to establish this national system. These components are: (i) a common scientific framework embracing the system's structure; (ii) a set of inter-institutional agreements and arrangements based on financial, technical and field capacities; and (iii) a cost-efficient working plan to ensure continuous national data gathering. The system will support data and information driven decision-making for national and international needs.

Addresses
[1] National Commission for the Knowledge and Use of Biodiversity (CONABIO), Mexico City, Mexico
[2] Institute of Ecology (INECOL), Veracruz, Mexico
[3] Institute of Biology, UNAM, Ciudad de Mexico, Mexico
[4] National Forestry Commission, Jalisco, Mexico

Corresponding author: Garcia-Alaniz, Nashieli (ngarcia@conabio.gob.mx, ngalaniz@gmail.com)

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Introduction

In 2015 the UN announced the sustainable development goals agreed by country members, which urged the world to pursue sustainable development in its three dimensions: economic, social and environmental in a balanced and integrated manner [1••]. This new global-scale agenda fosters the protection of terrestrial ecosystems by encouraging their sustainable use and pleads for halting and reversing both land degradation and biodiversity loss. In tune with these statements, current goals of relevant international initiatives, such as the Aichi Targets 2020, REDD+, IPBES, and GEOBON, promote to reduce biodiversity loss [2•,3,4••,5•].

Mexico has exceptional biodiversity. Situations, which have created awareness and commitment to conserve wildlife and their habitats through protection and optimal levels of sustainable use, are reflected in the national policy. The 'ecological integrity' concept or the equivalent 'functional integrity of ecosystems' is a criterion that is widely used in Mexican environmental legislation. The core federal instrument (*i.e.* the General Law of Ecological Equilibrium and Environmental Protection) [6] instructs that sustainable use of natural resources should be conducted to ensure that the functional integrity of ecosystems is preserved (Art. 3, Title I, Chapter I, Section III; Art.15, Title I, Chapter III and Section II). Functional integrity of ecosystems is also a relevant concept in normative instruments related to fisheries, forestry development and natural protected areas. Protected areas that are to be considered for incorporation into the National System of Protected Areas, must also present special relevance in the functional integrity of ecosystems (Art. 37, Title III, Chapter I, Section X).

Mexico has substantial databases to evaluate its natural capital. The National Forest and Soil Inventory (INFyS) under the responsibility of the National Forestry Commission (CONAFOR) collects data over more than 26 000 sites in 5 year cycles, covering more than 150 data items at each spot [7], and the National Information System on Biodiversity (SNIB) under the command of the National Commission for the Knowledge and Use of Biodiversity (CONABIO) which has some 10 million biotic records. Both are essential sources of detailed information on natural resources. Still, until now each system gathers data related to biodiversity with a fragmented approach (oriented to their individual mandates and institutional guidelines). The time and space coverage within these databases is also limited and this makes them inadequate to produce proper and reliable national evaluations.

Sustainable international practices and Mexican national aims need standardized relevant scientific information for policy. Also, a clear and coordinated link between scientist and policy makers is needed to establish a monitoring system of ecosystem change [2•,3,4••,5•]. In Mexico, we have developed the National Biodiversity and Ecosystem Degradation Monitoring System (SNMB for its Spanish acronym). This is a system created to follow ecosystem degradation and biodiversity change, designed by scientists in close collaboration with policy makers. This effort was aligned and boosted by the participation of Mexico in the development of international strategies such as the Reducing Emissions of Deforestation and Forest Degradation (REDD+) that has recognized the importance of conserving biodiversity to avoid creating perverse incentives and unintended harm to biodiversity. The SNMB also contributes to Mexico meeting the Aichi-Targets commitments under the Convention on Biological Diversity.

We conceived the entire system as comprised of three main interdependent building blocks: (1) the scientific and modelling proposal supporting the system, (2) the development of national and inter-institutional agreements, and (3) the operational framework to systematically collect data (Figure 1). Although the essential components have been widely discussed before [8–13,14••,15,16,17••,18] we found that they have to be coordinated to build a successful monitoring system. Discussing these three components as embedded in a cohesive process that enabled the establishment of the system, is deemed necessary. Thus, with data and structures already available, and congruent with national needs and global commitments, we have developed a system capable of generating standardized relevant scientific information for policy development. It is in its early stages, but it is already operational in Mexico.

Module I. The Common scientific framework

We aimed at building a reliable common conceptual framework based on robust scientific knowledge and highly intuitive content. The system developed uses as surrogate of biodiversity to measure ecosystem integrity [19] with compositional, structural and functional attributes as measured elements to asses it. Once established, this conceptual basis significantly helped articulate the communication between scientists and officials of the involved governmental agencies. Ecosystem Integrity is measured by how different an actual ecosystem is from some original and desired condition. The specific abiotic environmental setting present in a given area establishes the context for the compositional, structural and functional attributes, and these attributes can be measured to infer the Ecosystem Integrity (Figure 2). This approach uses remote-sensing and *in-situ* data monitoring and includes a modelling strategy that allows data integration from different sources. This allows its interpolation to produce full coverage maps of variables and indicators.

We performed a Bayesian network analysis [20] of Ecosystem Integrity with available information from Mexico (see Supplementary material Module I). We produced the first depiction of Ecosystem Integrity values at a high resolution of 1 km^2 under different scenarios for particular environmental conditions for La Sepultura, which is a Mexican protected area (Figure 3). This map illustrates the specific configuration of forests coverage in contrast to scrubs, even though the variables used in the model were the same for all available ecosystems throughout the country. It also contextualizes each particular ecosystem to its environmental setting and the assemblage of existing species in a region.

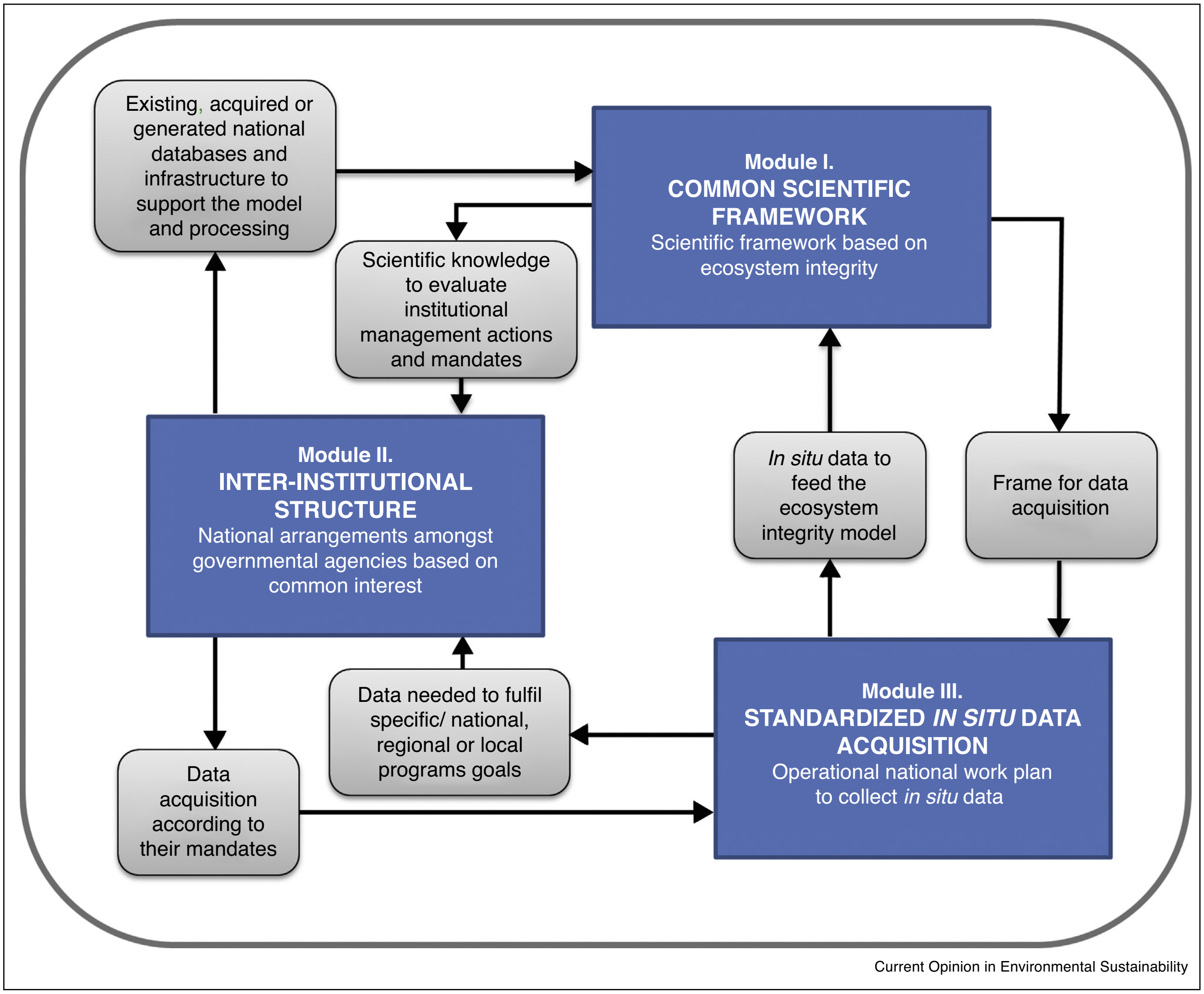
These results suggest that our conceptual framework offers a practical way to evaluate the condition of ecosystem assets using the available information. The way in which we can represent patterns of the state of biodiversity conservation with our approach could help define quantitative targets of Ecosystem Integrity and use these values to identify targets within management plans. This provides a common ground for monitoring ecosystem degradation and biodiversity change.

Module II. The Inter-institutional structure

To develop a coherent national monitoring system, we needed an inter-institutional structure to support it. With CONABIOs leadership, we fostered efforts between CONABIO, CONAFOR and the National Commission of Protected Areas (CONANP) to conceive a coordinated national initiative. Our concept took as keystone the recognition of these three leading environmental agencies,[1] separate mandates as a comprehensive whole, and distinguishing cooperative responsibilities and interests while: (1) using a common conceptual framework (described in Module I) and (2) and an operational proposal to orchestrate efforts which satisfy specific needs. With these underlying agreements, complementarity for the cost, technical and field capacities were examined.

[1] The National Commission for the Knowledge and Use of Biodiversity (CONABIO in its Spanish acronym); the National Forestry Commission (CONAFOR in its Spanish acronym); and the National Commission of Protected Areas (CONANP in its Spanish acronym) see supplementary material Module II and http://www.biodiversidad.gob.mx/sistema_monitoreo/.

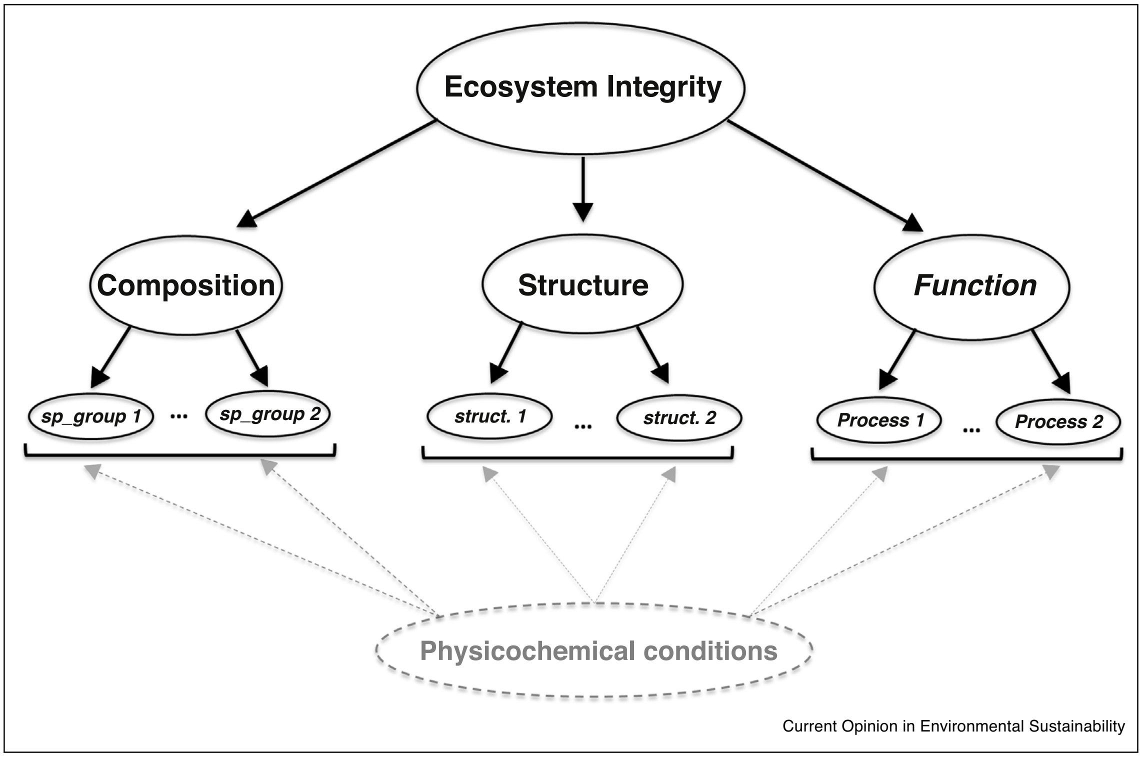
Figure 1



Interdependent components of the México's National Biodiversity Monitoring System **Module I.** Shared understanding of biodiversity concept used as a joint framework for all agencies involved. An approach based on ecosystem integrity (EI). The model has the capacity providing information on indicators, to ascertain the state for a certain degree of Ecosystem Integrity change under some biogeographic context. The farther an ecosystem is from its original integrity condition, the more degraded it is and the more altered the range of goods and services it produces in comparison to its original self-organized condition. **Module II.** Mandates and missions need to be analyzed to recognize overlaps and identify concrete synergistic opportunities to build an efficient plan. Identifying differential responsibilities and interests required to create a monitoring plan that satisfies specific needs and task within the cooperative effort. **Module III.** The monitoring approach based on a large scale, large multifunctional landscapes and entire ecosystems.

Taking advantage of the already massive infrastructure of the INFyS and the Mexico's protected area network, the SNMB obtains data for two complementary spatial extents. At the nationwide level, the system is being implemented by CONAFOR-CONABIO to achieve large area coverage with a short time-frame resolution. Subsets of sites from the INFyS were selected to collect information with only small extra costs, using the agencies current field and technical capacities. As an enhanced variant, the system is being implemented by CONANP and CONABIO on initially selected national protected areas. The system is rendering a higher temporal resolution by taking several samples per year. CONANP is raising funds to maintain and increase the deployment of the system in the future, while relaying operation to SNMB with exiting personnel and field capacities. All information produced is stored in CONABIO databanks, where investments currently expand capacities for storage, management and analysis of these national databases. The information produced will be available to the participating agencies and generate greater benefits than each agency's individual investment. Information

Figure 2



The ecosystem integrity approach. The physicochemical setting present in a given area (bottom) establishes the context for the composition, structural and functional attributes (middle). The interaction amongst these is then associated with an ecosystem integrity condition (top).

will also be made available to the scientific community and the general public.

This platform has stimulated governmental agencies to shift to a science-based parsimonious and effective joint planning for biodiversity monitoring and promoting the efficient use of resources for national strategic planning. The inclusive and shared approach will generate information that eventually will permit to respond in a transparent and coordinated fashion to achieve the national environmental goals and the various binding mechanisms to which they all are subjected.

Module III. Standardized *in situ* data acquisition for monitoring

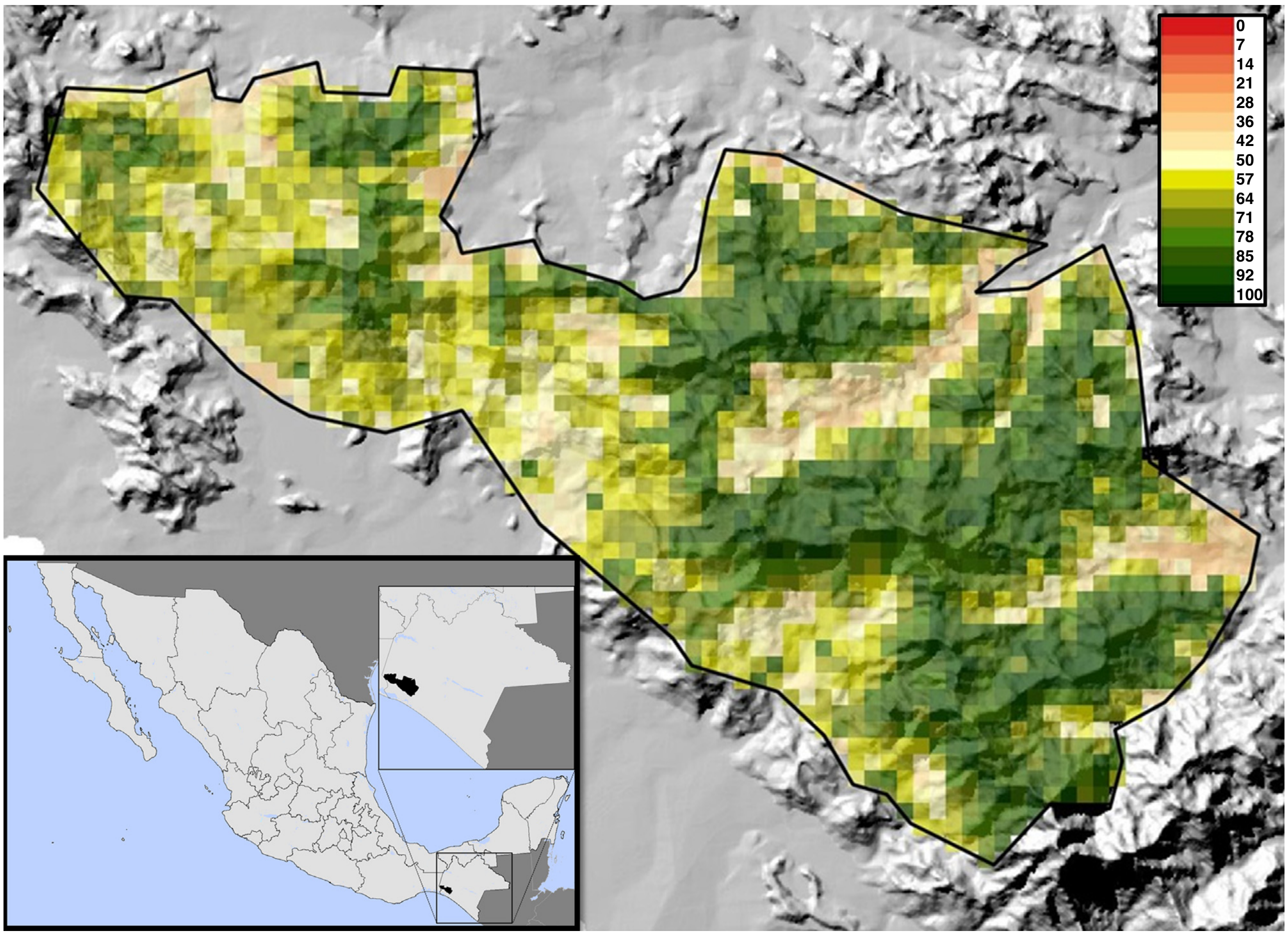
Work described in Modules I and II, allowed us to propose an operational structure covering training, fieldwork, data management and analysis. We identified three main research lines to build the system's operational structure cost-efficiently: (i) where to sample, (ii) what variables or information are needed, and (iii) what methods are adequate for the sampling procedures (see supplementary material Module III).

To define where to sample, we used the current extensive infrastructure of INFyS that has a sampling scheme based on a systematic grid of 5–20 km^2 (according to biome type) all over continental Mexico [7]. We designed a new representative sample scheme for this system and conducted a spatial analysis by overlaying the forest inventory data, biotic survey data from the National Biodiversity Information System and satellite-derived land-cover data. Our final grid included 8000 sites that will be sampled with a 5-year turnover cycle (see Supplementary material Module III).

To define what variables should be sampled, we extensively evaluated the available databases for the country. To have information that could improve in the future Ecosystem Integrity assessments and also seek cost-effectiveness, we resorted to collecting data in three broad categories: (a) fauna and invasive species; (b) vegetation structure (complementary to what INFyS is already collecting); and (c) information on the general environmental condition of the sampled site.

To define what methods to use, we considered cost effectiveness and the large variety of Mexican ecosystems. One criterion to satisfy these conditions was to avoid dependency on site-specific experts to undertake the massive sampling chore. We therefore opted for (all-encompassing) multi-taxon methodologies [21,22] and

Figure 3



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Ecosystem integrity in the Biosphere Reserve La Sepultura, Chiapas, Mexico, using *in-situ* variables from the National Forest Inventory analysed under a Bayesian network approach. Having 0 as the lowest ecosystem integrity value and 100 highest ecosystem integrity value.

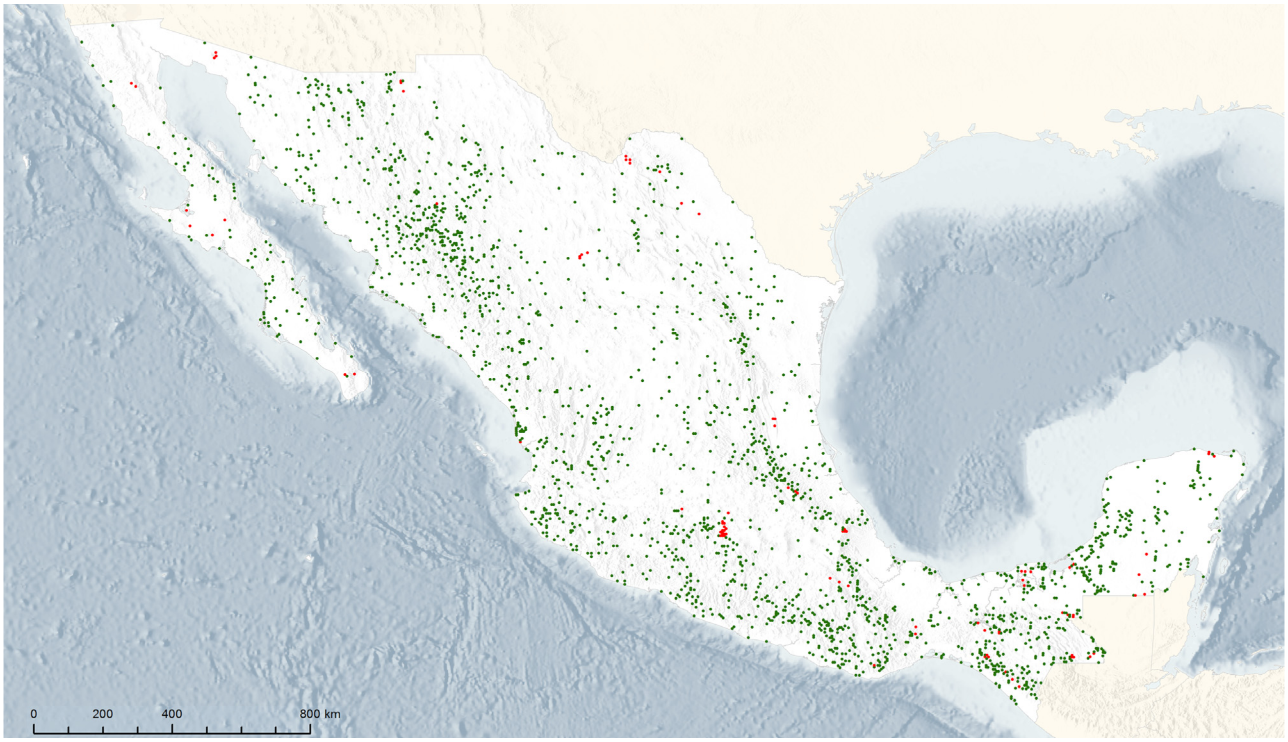
favoured data sampling that could be corroborated at a later time (to ensure traceability) and person-independent sampling (to ensure replicability).

We specifically developed national standardized protocols, including a mobile application for data capture and storage, under the systematic national database structure. With this operational plan, personnel was trained and nation-wide sampling is currently implemented.

The system has a sampling coverage with two resolutions (Figure 4) and, since its start in 2014, over 2150 sites have been sampled with all these methods (see Supplementary material Module III and http://snmbserve.conabio.gob.mx/app/). With the obtained field data, the monitoring system can annually produce ecosystem integrity assessments at a 1 km^2 resolution.

The EI index will provide information to promote sustainable use of biodiversity as stated in the Mexican environmental legislation. It includes an assessment on deforestation and degradation of ecosystems related to their functioning biodiversity contents. This enables the response to initiatives like REDD+ that requires reporting on tree and carbon densities together with data on biological diversity as a co-benefit. This analysis also provides information on how biodiversity contributes to carbon stocks and their role in the resilience of ecosystems producing and articulating strategic information to assess degradation and fragmentation of ecosystems as agreed in the Aichi Targets 5 to 15 of the Convention on Biological Diversity, and at least on six of the fifteen UN sustainable development goals. However, our gathered field information also generates indices and indicators in tune with other international initiatives. For example,

Figure 4



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National Biodiversity Monitoring System implemented in Mexico. The system has a sampling coverage with plots throughout the country. So far, a total of 2150 sites has been sampled with two slightly different slants. At the national level (green dots), the system is executed by the National Forestry Commission (CONAFOR for its Spanish acronym) and the National Commission for the Knowledge and Use of Biodiversity (CONABIO for its Spanish acronym) to achieve large area coverage with a short time-frame sampling resolution at each site. At locally relevant scale (red dots) the effort is undertaken in the national protected areas managed by the National Commission of Protected Areas (CONANP for its Spanish acronym) and CONABIO. CONABIO provides the national utility storage facility, data processing, and information extraction power, making results available and accessible to end users.

GEO-BON developed a set of Essential Biodiversity Variables that define a basis for monitoring programs worldwide [14••]. Such variables are collected in the SNMB and they connect to the necessary information related to species population, species traits, community composition, ecosystem structure, ecosystem function, that are explicitly linked to various Aichi Targets.

Conclusions

Mexico produced a working Ecosystem-Integrity monitoring system in response to both national needs and international commitments. This system is based on remote-sensing and on an extensive network of field data collation. It is based on an advanced statistical and computational platform. Within just two years of its implementation, the Mexican National Biodiversity and Ecosystem Degradation Monitoring System is already producing terabits of high-resolution and standardized biodiversity data in more than 2150 sites, over a systematic grid throughout its national territory, building a time series with spatial, temporal and methodological repeatability.

The system's value lies not only in the production of relevant biodiversity information that can be used to calculate Ecosystem Integrity as required by the Mexican legislation, but also in the inter-institutional cooperation of government agencies by making the data available for participating agencies and citizens. These major challenges were addressed while designing and developing the system. Although on its early stage, the substantial wealth of high-resolution and standardized biodiversity data in combination with its advanced modelling tools will support both nationally data-driven decision-making and the binding conventions to which Mexico is committed.

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283093, entitled Role of Biodiversity In Climate Change Mitigation (ROBIN), provided funding to develop the conceptual framework, methodologies, and analysis presented here. The Gordon and Betty More Foundation provided funding for training people in the standardized protocols and acquisition of starting-up equipment and the Mexican Fund for the Conservation of Nature coordinated this process. The National Forestry Commission trough the Department of Geomatics and Forest Inventory provided funding for the pilot process at a national scale and has funded sampling of more than 2000 sites. The National Commission on Protected Areas is currently coordinating and supporting the implementation in protected areas of national priority. Presently personnel for 36 protected areas has been trained and equipped. We thank anonymous reviewers for comments that substantially improve the manuscript. We thank Dr. José Sarukhán Kermes who supported this initiative since the beginning. We thank Yusen Ley Cooper (Geoscience Australia, Canberra, Australia) and Marisa Mazari Hiriart (UNAM, Mexico) for comments on the paper and the Institute of Ecology, UNAM for hosting GA, as a postdoctoral researcher in 2012. We thank M. Tschapka (Univ. Ulm, Germany) and R. Medellin (UNAM, Mexico) for input to the early design of the bat monitoring feature of the system.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cosust.2017.01.001.

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- • of special interest
- •• of outstanding interest

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Ecosystem integrity and policy coherence for development

Tools aimed at achieving balance as the basis for transformative development

Harlan Koff, Miguel Equihua Zamora,
Carmen Maganda, and Octavio Pérez-Maqueo

> plus ça change, plus c'est la même chose (the more things change, the more they stay the same).
>
> —Jean-Baptiste Alphonse Karr

Introduction

If aliens were to look down on planet Earth and observe us, they might be led to believe that the natural state of humanity is crisis. Whether we focus on politics, economics, society or the environment, it seems that crises are perpetuated and possibly even expanded in global affairs. For example, we have recently witnessed war in places such as Afghanistan, Iraq and Syria, expanded flows of refugees and the resulting nativist fears expressed in those countries where they arrive or could potentially arrive, unprecedented global financial crises, the depletion of natural resources and our alleged contribution to deadly disasters (such as Typhoon Haiyan in 2013) through climate change. Borrowing from Jean-Baptiste Alphonse Karr's observation of 19th century French politics, we may argue that "the more things change, the more they stay the same." (http://www.histoire-en-citations.fr/citations/Karr-plus-ca-change-plus-c-est-la-meme-chose)

However, should we really argue that "crisis" represents the state of our times? While conflict certainly does exist, it is important to note that we are also witnessing unprecedented levels of international cooperation as evidenced by the consensus behind the 2000 Millennium Development Goals and the 2015 Sustainable Development Goals. These declarations are sym-

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bolically important because they have introduced the fight against poverty and the struggle for sustainable development into the global political consciousness. Nonetheless, in policy terms, their impacts have been limited. For this reason, this article contends that new paradigms and metrics should be proposed on which to base our global, national and local development debates. It proposes "balance" as a potential cornerstone for development discussions. First, this approach rejects the "North–South" paradigm often proposed in development debates. This distinction reinforces development divides instead of helping overcome them. The notion of "balance" is based on "interactive" development relationships in which policies and processes in one sphere or geographical region affect others in different spheres/regions. This approach reflects what Jens Martens of the Global Policy Forum has dubbed "universal development goals" (Martens, 2015).

Second, the notion of "balanced development" includes considerations related to the ecological, ethical and cognitive spheres of development processes. "Conservation," for example, favors ecological approaches (such as willingness to pay for ecological services), and it acknowledges the importance of preserving natural resource renewability. However, because it has often focused on the restriction of natural resource use and the maintenance of traditional economies, it also often "conserves" social marginalization as an unintended consequence. Similarly, "human development" focuses on processes aimed at reinforcing the capacity of individuals to control their own destinies without necessarily including environmental considerations.

For these reasons, this article contends that "balanced" development can be transformative in nature, meaning that it can address local problems and global inequalities simultaneously by aiming to promote equilibria within and between these systemic levels. In order to achieve this goal, the article proposes a partnership between two concepts that have been evolving for some time and now emerge as "conceptual attractors" inspired by the 2030 Sustainable Development Agenda: Ecosystem Integrity and Policy Coherence for Development. The combination of these paradigms includes both metrics aimed at balanced development strategies (the former) and policy tools aimed at "balance between policy arenas" (the latter). By combining these approaches, the analysis presented here aims to show pathways that could re-orient development policies towards measurable and achievable goals.

Ecosystem integrity: Sustainability through holistic means

How can science impact policy? One means is through the formulation and application of metrics that are used by decision-makers as the basis for their deliberations. This has traditionally been problematic in the field of sustainable development due to the complexity of causal grids. Discussions over definitions of paradigms, such as "ecological footprints," "ecological shadows," "greenhouse development rights," and so forth, have dominated scientific and policy discussions, especially in relation to climate change, where debates have often been characterized by accusations related to the adage famously quoted by Mark Twain that "there are three kinds of lies: lies, damned lies, and statistics" (www.gutenberg.org/files/19987/19987-h/19987-h.htm). More recently (and more rationally), Nobel Prize Winners Amartya Sen, Joseph Stieglitz, and Jean-Paul Fitoussi have reminded us that "what we measure affects what we do" and more specifically "we often confuse means and ends" (2010, p. xvii).

This point is present in contemporary climate change debates. Why do we wish to address climate change? Is it to prevent global warming itself, or to mitigate the destructive impacts of global warming on human populations? The question is not simply rhetorical because it affects policy. When we discuss mainstreaming of climate change mitigation by integrating these strategies in general governance systems, then we filter a single sustainable development tool, aimed at addressing one environmental issue through policy making in other arenas. Instead, shouldn't we be prioritizing the health of ecosystems more generally by adapting other policy strategies related to development toward their protection, thus addressing climate change along with other issues, such as biodiversity, the effective use of water resources, land governance, energy, and so on?

This paradigm shift that started with the "World We Want" Campaign and continued through the announcement of the 2015 Sustainable Development Goals focuses on the relational bases of development, including access to water and sanitation, food security, biodiversity, climate change, energy and equitable relationships between world regions (sustainabledevelopment.un.org/?menu=1300). For these reasons, this article highlights the use of "ecosystem integrity" as a methodology for the measure of human impacts on the environment and the ecological consequences of development models. It is a scientific paradigm that fits the political needs of the present global development agenda focused on complex human–environmental interactions.

Unlike methodologies traditionally referenced in policy debates, such as Integrated Water Basin Management, Integrated Land Management or Climate Change Mainstreaming, ecosystem integrity is not sector specific and it does not prioritize any single issue, so it focuses on bolstering sustainable development through a holistic approach. It also differs significantly from newer interactive barometers, such as the Global Climate, Land, Energy and Water Strategies (CLEWS) measures developed for the Rio + 20 Summit (https://unite.un.org/sites/unite.un.org/files/app-global-clews-v-1-0/landingpage.html), because it aims to examine the impacts of policy changes on relationships in ecosystems rather than simulating the impacts of physical changes in one arena on physical changes in another. Whereas CLEWS documents impacts of global shifts in climate change on energy, land and water, ecosystem integrity attempts to actively promote monitored ecosystem alterations coupled with measurements of policy change impacts, and the methodologies proposed through this approach can be adapted to local, national or even supranational contexts.

Although the use of ecosystem integrity will not solve by itself the conflict between conservation of nature and social marginalization described earlier, it promotes balance in two specific ways: (a) it provides an operational conceptual framework to assess the interactions between human activity and natural systems; and (b) it supports practical measures for keeping the strain on the environment created by human activity within "acceptable limits" (a tough target given current ecological knowledge) by preserving enough areas with their natural functional ecosystems. Ecosystem integrity recognizes the interdependence between biological conservation and human impacts that compromise public health, vulnerability to disasters, economic potential of communities (which is a means to address poverty through sustainable development practices), and so forth. Moreover, the ecosystem integrity model can be applied equally well to urban and rural areas, which adds a comparative dimension to the analysis. Even though cities do not have the same robust ecosystem diversity found in many rural areas, the framework can propose reasonable standards for natural integrity in urban areas In this regard, the model can both document shifts in ecosystem integrity in defined territories, and it can prescriptively promote integrity standards and maintenance strategies, depending on the needs of stakeholders.

Another key characteristic of the ecosystem integrity approach is its focus on self-regulation. Integrity is defined as a system that maintains its organization in the face of changing environmental and socioeconomic conditions. In this regard, a balance between human–environment interactions is present in the ecosystem's regulatory dynamics. Both the natural system and human communities are participants in this regulatory system, and they must work in synergy for integrity to be maintained. It is this characteristic of the ecosystem integrity framework, which links the ethical, cognitive and environmental aspects of the model. This is discussed in the following section, which shows the empirical application of ecosystem integrity analysis to Mexico.

Ecosystem integrity in Mexico: A preliminary study

Ecosystem integrity is based on a three-tier model focused to estimate the integrity condition of different ecosystems (see Figure 1 for a general description of the model). This condition is calculated using artificial intelligence techniques, Bayesian networks in particular. Contrary, to ad hoc indices, this is a data-driven approach from which the level of integrity (in the hidden tier) is obtained according to the patterns of correlation among variables (in the instrumental tier), which are specific for each type of eco-

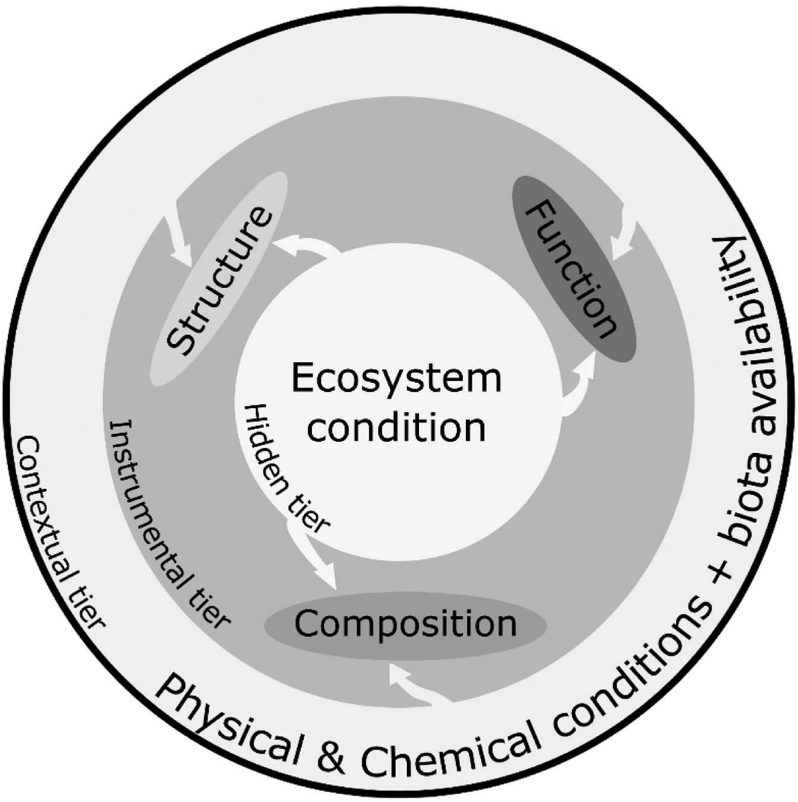

Figure 1 • Three-tier model of ecosystem integrity (3TEI)
The inner tier is hidden to the observer, but its status can be inferred by the information available at the instrumental tier as measurements on structure, function and composition, of course considering the context where the ecosystem is developing. Arrow tips indicate direction of assumed mechanistic influence, although information can go either way.

Source: Miguel Equihua, Octavio Pérez-Maqueo (concept), and Pedro Maeda (design) system (as defined in the contextual tier). In adherence to this conceptual framework, we propose that it is possible to get an estimate of ecosystem integrity using the available data for each case. Obviously, for comparative purposes, data similarities or calibration exercises are required.

In order to apply the model, remote sensing and field variables are utilized, and in doing so, we can estimate the integrity of terrestrial ecosystems per square kilometer for any territory using Bayesian networks structured according to the three tier model (for the empirical application of this model to Mexico, see Equihua Zamora, et. al., 2014).

Furthermore, ecosystem integrity can be mapped and assessed over time, providing a suitable measure of "environmental change." Thus, the estimates of changes on ecological condition could be used to follow upon the impact of different policies, plans and projects over time. For example, the level of integrity assets that could be at risk given the potential development of a mine for metal ore extraction, can be analyzed in terms of the alteration of involved ecosystems with reference to their previous general assessment available for the location, and even followed up because of the national monitoring taking place, which of course could include additional data specific to the facility under scrutiny.

Ecosystem integrity can be spatially represented as maps, but it can also be related with other metrics. For example, we believe it is possible to devise different dose-response curves to estimate the cost of different policies in terms of ecosystem integrity. In the near future it will be possible to compare and analyze the impact of different development policies acting at the same time in a specific place, fostering a holistic perspective building upon the opportunities that the ecosystem integrity framework coupled to human evaluation of natural assets can provide.

Policy coherence for development: A strategy for achieving policy balance

Like our metrics related to development, policy approaches have also favored sector-specific strategies. For decades development aid promoted indicator-based and specialized projects that focused on specific objectives, many of which were material and focused on promoting economic growth (see Mawdsley, Savage, & Kim, 2014). Development policies forwarded by international organizations, such as the World Bank defined development as interconnectedness in global markets and "development" was measured through increased production (Rich, 2013). Development performance was based on the efficient achievement of project deliverables (Denizer, Kaufmann, & Kraay, 2013). Natural resources such as water and land were integrated into visions of development based on the provision of goods with less visible attention to human rights or the transfer of ownership of development programs related to these essential goods (many of which were tied to privatization schemes) to aid recipients.

This scenario has shifted significantly since 2010. By 2011, The Busan Partnership for Effective Development Co-operation established international criteria for development aid partnerships between public, private and civil society organizations including: (a) ownership of development priorities by developing countries; (b) a focus on results as sustainable impacts should be the driving force behind investments and efforts in development policy making; (c) the promotion of partnerships for development, which depends on the participation of all actors and recognizes the diversity and complementarity of their functions; and (d) transparency and shared responsibility (http://www.oecd.org/development/effectiveness/busanpartnership.htm). These "post-aid" partnerships were integrated into the 2015 Sustainable Development Goals as SDG #17. Furthermore, these development partnerships were the focus of the Third International Conference on Financing for Development held in Addis Ababa, Ethiopia in 2015.

The field of sustainable development is moving away from vertical organization and institutionalization through the emergence of development partnerships and shared responsibility. This paradigm shift actually makes development policy frameworks more compatible with ecosystem integrity. Specific policy tools have been identified by international organizations, such as the United Nations, the Organization for Economic Co-operation and Development (OECD), and the European Union (EU) as well as development aid donors in order to promote development strategies that include a plurality of actors and focus on relationships between development spheres.

The most prominent of these tools is policy coherence for development (PCD), which has been recognized as a key policy paradigm for the implementation of the 2030 Sustainable Development Agenda. PCD is defined as "working to ensure that the objectives and results of a government's (or institution's) development policy are not undermined by other policies of that same government (or institution), which impact on developing countries, and that these other policies support development objectives where feasible" (OECD, 2005, p. 28). At the minimum, coherence means "doing no harm." More ambitiously, it calls for "the systematic promotion of mutually supportive policies…to help achieve mutually agreed international goals" (OECD, 2005, p. 23).

Political and academic recognition of the importance of PCD has evolved significantly since the early 1990s. The EU first adopted PCD with the Maastricht Treaty in 1993 (Hoebink, 2004) and the Cotonou Partnership Agreement in 2000 (Laakso, et al., 2007). However, only in 2005 was PCD established on the EU agenda with the Commission adopting a communication with a focus on PCD and the EU Council adopting conclusions on PCD (CEPS 2006). PCD was also integrated into the EU development policy program, (European Consensus on Development, EU 2006). The Lisbon Treaty of 2009 further reinforced the Union commitment to PCD, stating that "the Union shall take account of development cooperation in the policies that it implements which are likely to affect developing countries" (Art. 208). The EU is also committed to a biannual PCD reporting process (EC 2007, 2009, 2011). In 2007, the decision was made to focus on five priority areas: trade and finance, climate change, global food security, migration, and security. In 2010, the European Commission presented the PCD Work Programme (EC 2010) for the years 2010 to 2013, structured around the five priority areas.

PCD has also been on the OECD agenda since the early 1990s. The 2002 Ministerial Statement (OECD Action for a Shared Development Agenda) points out that, when formulating policies across the policy spectrum, OECD countries should take account of the potential impact on developing countries. In response to the 2002 Ministerial Statement, the OECD launched a program on PCD (OECD 2005). In 2008, ministers of OECD countries adopted the Declaration on Policy Coherence for Development (OECD 2009). The Development Assistance Committee (DAC) of the OECD, which includes most EU member countries and the European Union, has organized peer reviews of its member states' development policies, where policy coherence has received growing importance. In 2007, the Development Co-operation Directorate and the Development Centre of the OECD jointly created the OECD Network of National Focal Points for Policy Coherence for Development ("the PCD Network") "to establish better communications between the OECD and officials in capitals on policy coherence for development." At the meeting on 9 February 2012 in Paris, the Network envisioned that PCD would be a core element of the new sustainable development paradigm (OECD 2012).

As PCD emerged in policy documents emitted by the OECD and the EU, academics began to take note of the importance of this policy tool. The first academic studies by scholars such as Forster and Stokke (1999), Hoebink (2004), Carbone (2008) and Picciotto (2004) examined the state of PCD in different polities (the EU, European states, the United States, Japan). As the literature began to develop, scholars began to examine specific issue arenas such as security (Picciotto, 2004), trade (Stocchetti, 2016), and migration (Nyberg-Sorensen, 2016). More importantly, great conceptual strides have been made in defining PCD and identifying typologies (see Table 1).

Table 1 • Typologies of policy incoherence for development

Horizontal incoherence	Incoherence between development aid and non-aid policies
Vertical incoherence	Incoherence between policies of regional organizations and member states
Inter-donor incoherence	Incoherence between development policies of a region's different member states
Internal incoherence	Inconsistencies between the objectives and means of a given policy
Inter-organizational incoherence	Incoherence between the development policies of a donor country's government and civil society organizations
Multilateral incoherence	Incompatibility between the development goals and procedural norms of international organizations such as the EU, OECD, the UN, and the international financial institutions
Donor-recipient incoherence	Incoherence between development strategies in donor states and those in aid receiving states
Normative incoherence	Incoherence between policy strategies in development and nondevelopment policy arenas and core values of liberal democratic societies

Source: Koff, H. (forthcoming). "Diaspora Philanthropy in the Context of Policy Coherence for Development: Implications for the post-2015 Sustainable Development Agenda." *International Migration*.

The recognition of different coherence/incoherence frameworks and the combination of these frameworks re-focuses policy paradigms away from specific objectives and more toward holistic impacts. In the field of sustainable development, PCD has received prominent attention in fields such as agricultural policy (see Carbone, 2009; Matthews, 2008), fisheries (Kazcynski & Fluharty, 2002), biodiversity (Nilsson, et. al., 2012), energy (King, et. al., 2013), food security (Lundstrom Sarelin, 2007), climate change (Kok & de Coninck, 2007) and water (Koff & Maganda, 2016). While this rich literature recognizes the relevance of PCD to sustainability debates, it applies this analysis to specific development projects or development aid programs. As Siitonen (2016) has illustrated, PCD studies have been limited to the actions of donors. Instead, there is dearth of PCD analysis focusing on development aid recipients or relationships between regions. This article argues that PCD can become innovative from a policy standpoint when applied to specific development contexts, such as water basins or clearly defined ecosystems. While current uses of PCD as a policy tool highlight its strengths because they prioritize sustainable development over competing policy arenas and they identify specific challenges regarding development policy implementation, contemporary approaches only scratch the surface of PCD's potential contributions to transformative development as previously defined. Instead, the application of PCD to different scales of analysis could maximize its policy impact.

This approach is highly salient to ecosystem integrity debates. As stated earlier, ecosystem integrity is an approach to sustainable development that highlights relational mechanisms. Like ecosystem integrity, PCD not only examines the mechanisms that affect policy implementation within specific arenas but also investigates the relationships between policy arenas, policy actors, policy levels and policy norms (see Figure 2). PCD analysis can be used to map policy-making within specific ecosystems and examine how policy arenas, levels, norms and actors affect each other in development policy systems. Also, like ecosystem integrity, PCD focuses on self-regulation mechanisms as it includes analysis of social participation in the definition, implementation and monitoring of policies.

For example, payment for ecological services (PES) have become an important policy mechanism for conservation in Mexican water basins. One area where PES programs have been implemented is La Antigua Basin in the Mexican State of Veracruz. La Antigua is a basin that extends 2,326.43 square km from the Gulf of Mexico to the center of the state. The

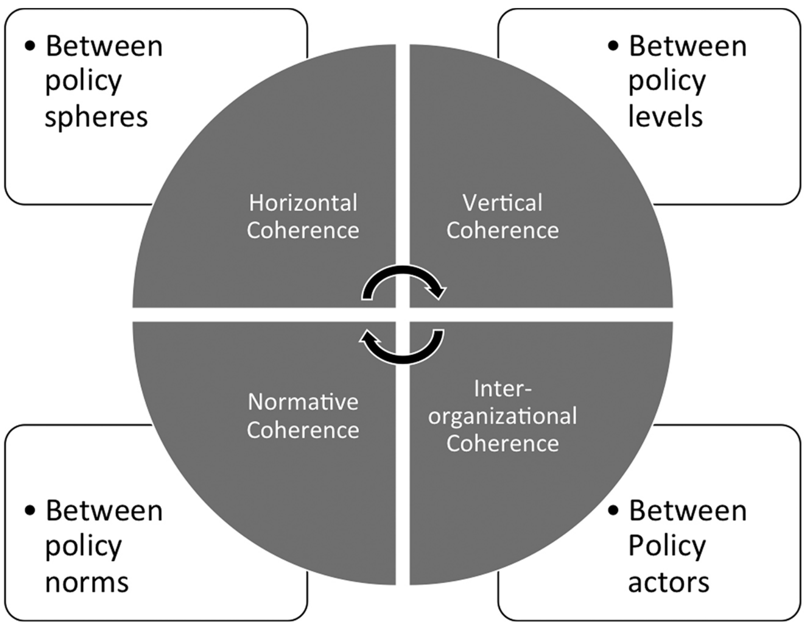

Figure 2 • Main dimensions of ecosystem PCD
Source: Harlan Koff (concept and design)

basin is characterized by high biodiversity including pine-oak forest, cloud forest, deciduous forest, riparian vegetation, induced and cultivated pasture (http://www.conabio.gob.mx/conocimiento/regionalizacion/doctos/rhp_077.html). In addition to the wide variety of plants found in the different forests in the basin, numerous fish and amphibious species live there as well. In terms of economic activities, the basin fosters shrimp fishing, coffee (some under forest cover) and sugar cane production and seasonal agriculture. Moreover the sustainable tourism sector has begun to emerge around the Antigua River and its tributaries, where rafting and other outdoor sports have become popular.

These economic activities, especially farming and the limited industry that exists in the basin have threatened the local ecosystem. The Antigua River has been polluted by the runoff of chemicals used for agriculture and domestic use as well as waste associated with coffee production. Moreover, clandestine logging has led to deforestation, the uncertainties in coffee pricing to sugar cane expansion and a recent attempt to build a dam near the town of Jalcomulco in order to provide energy for the national interconnected system and fresh water to Xalapa (the State capital), threatens sustainable tourism in the region, which attracts more than 40,000 visitors per year (personal interviews with tour operators and political organizers, 14 March 2016, Jalcomulco). Research has shown that the deterioration of water quality includes substantial increases in e-coli bacteria which augmented the incidence of disease in the basin (Mokondoko Delgadillo & Manson, 2010). Furthermore, CONABIO (Mexico's National Commission for Knowledge and Use of Biodiversity) has found that water pollution has undermined the population of tree frogs in the basin, which are used as indicators of ecosystem integrity because they depend on pure water (http://www.conabio.gob.mx/conocimiento/regionalizacion/doctos/rhp_077.html).

In response to these threats, PES programs have been introduced in the basin by both local and national agencies. These policies, instituted by Mexican federal agencies like CONAFOR and local governments (FIDECOAGUA), pay landholders between 500 pesos/ha per year and 1,000 pesos/ha per year in order to conserve both forests and water resources (Fuentes Pangtay, 2012). Some of the policies, such as the local government program in the town of Coatepec, bill water users for PES in the Pixquiac micro-basin in order to broaden public participation in the program. These increases in local water bills have created controversy amongst some local participants.

Thus far, reviews of these policies have focused on the distribution of economic costs and benefits of these payment programs as well as the need for social participation in their definition and implementation in order to promote buy-in among potential contributors (especially water users). However, a preliminary PCD analysis of these programs indicates that economic incentives and political participation are not the only factors that impact the success of these policies. Numerous policy incoherences exist that undermine the success of PES programs. In terms of the conservation of the ecosystem, PES projects are weakened by horizontal incoherences, such as a lack of health and sanitation regulations for livestock, which contaminate water resources and contradicting subsidies as CONAFOR, Mexico's forestry service, pays landholders to plant trees on their properties while SAGARPA, Mexico's agriculture service provides subsidies to promote the raising of goats that eat the saplings (personal interview with development official, 23 June 2016, Xalapa). Other incoherences, to name a few, include: (a) vertical incoherence as CONAFOR utilizes national mapping as the basis for its subsidy programs that do not break down districts into the micro-basins represented by municipalities (some of which have their own PES projects); (b) internal incoherence as PES programs are based on subsidies that do not promote economic transformations toward sustainability, thus promoting financial dependence on these programs; and (c) normative incoherence as PES focuses on conservation of natural resources without significantly addressing social marginalization, thus limiting the long-term transformative impacts of the programs. Identifying these policy weaknesses can already contribute to the establishment of ecosystem integrity-based policies because weaknesses in sustainable development relationships are highlighted, and thus, they can be collectively addressed by water basin stakeholders. This informs balanced sustainable development strategies.

Conclusion

The year 2015 was supposed to represent a seminal moment in the global development agenda because of the declaration of the Sustainable Development Goals. First, the number of goals was expanded from eight objectives included in the Millennium Development Goals to 17 declared objectives under the SDGs. Second, the Sustainable Development Agenda derived from the UN-sponsored "World We Want" campaign in which citizens, civil society organizations and businesses were invited to provide input to the post-2015 global development agenda. Thus, the SDGs are intended to reflect a more inclusive approach to development policy-making. Finally, the SDGs, as previously mentioned, include a stronger focus on the relational aspects of poverty, especially through the inclusion of SDG #10 (Reduced Inequalities), SDG # 11 (Sustainable Cities and Communities), SDG # 12 (Responsible Consumption and Production), SDG # 16 (Peace, Justice and Strong Institutions) and SDG # 17 (Partnerships for the Goals).

The 2030 Sustainable Development Agenda is in fact an impressive and ambitious policy framework. The 17 goals include 169 targets and 230 indicators. The question remains however, how transformative the SDGs will be. For the SDGs to be more than a quantitative expansion of the MDGs, a qualitative change must occur in the implementation of the goals. The inclusion of the relational goals mentioned earlier is a productive platform from which balanced transformative development can emerge. However, the way that the different goals are addressed must become more coherent. Transformative and balanced development should, for example, discuss how water security, food security and sustainable production and consumption mutually interact. Also, relationships between sustainable energy sources, climate change and biodiversity need to be highlighted. Policy coherence for development has already been identified as an important tool for the implementation of the 2030 development agenda in response to these issues.

However, the impact of PCD can be limited if it is only used as a policy tool aimed at improving the efficiency and effectiveness of development aid. PCD's influence can be expanded should its normative aspects be prioritized. What kind of sustainable development does PCD promote? Another important question asks: sustainable development for whom? This article contends that PCD should not be limited to development aid programs. Instead, its impacts can be magnified should PCD be systemically applied to different levels of analysis, such as territorially defined ecosystems or water basins. This shift in focus is important for two reasons. First, it applies PCD to development actions on the ground, where development policies are implemented on a daily basis. Second, by applying PCD to ecosystems, water basins, and so forth, leaders are making a political statement that development policies should focus on natural boundaries instead of political or administrative ones. This promotes a vision of balanced transformative development that highlights human–environment interactions.

This holistic approach should also have a strong ethical foundation. Ecosystem integrity provides such bases. Like PCD, this paradigm focuses on the relationships between different policy arenas and their impacts on the health of ecosystems and the communities that interact with them. The approach integrates cognitive, ethical and environmental policy considerations and most importantly, it provides a defined vision of sustainable development that is both conceptually ambitious and operationally practicable on the ground. In short, it provides an appropriate framework for the needs of the 2030 Sustainable Development Agenda. Combined with

PCD as a policy methodology, ecosystem integrity can contribute to transformative development through actions aimed at introducing balance to an unbalanced world.

HARLAN KOFF is Professor of Social Sciences at the University of Luxembourg, President of the Consortium for Comparative Research on Regional Integration and Social Cohesion (RISC) and co-editor of *Regions & Cohesion* (Berghahn Journals). He conducts comparative research on international development, regional integration processes, border politics, and migration.

MIGUEL EQUIHUA ZAMORA is a biologist who graduated from UNAM in Mexico City, where he also studied applied statistics. He holds an M.Sc. degree in biological computation and a Ph.D. in ecology from the University of York, UK. He is currently a Senior Scientist and Professor at the Instituto de Ecología, AC (Inecol/CONACyT) in Xalapa, Veracruz, Mexico and a member of the Mexican System of Researchers. He is the author of nine books and seven book chapters and more than 50 research articles. He has published a number of contributions on ecological subjects for the general public. His current research interests include the development of practical tools to understand and monitor environmental change and its implications for the functioning of ecosystems and the provision of ecosystem services. He is member of the CONACyt Network on Socio-ecosystems and Sustainability (Red CONACyT de Soci-ecosistemas y Sustentabilidad (RedSocioEcoS).

CARMEN MAGANDA is Assistant Professor of Environment and Sustainability at the Instituto de Ecología A.C. (INECOL) and co-editor of the scientific journal *Regions & Cohesion* by Berghahn Journals. She holds a Ph.D. in Social Anthropology, from the Centro de Investigaciones y Estudios Superiores en Antropologia Social (CIESAS) México, plus three postdoctoral stays in the U.S.A., France, and Luxembourg. Dr. Maganda's present research focuses on sustainable environmental development, the relationship between society and nature, transboundary waters, water security, water justice, and the socioenvironmental approach of political ecology. She also is exploring the social aspects of alternative agriculture models for sustainable production in Mexico and comparative contexts. She is member of the CONACyt Network on Socio-ecosystems and Sustainability (Red CONACyT de Soci-ecosistemas y Sustentabilidad (RedSocioEcoS).

OCTAVIO PEREZ-MAQUEO is Professor in the Network of Environment and Sustainability at the Instituto de Ecología A.C. His research interests include assessing ecosystem integrity and understanding its relationship with human wellbeing. He has worked on the assessment of ecosystem services and on the evaluation of coastal wetlands for hurricane protection. In addition to scientific publications, he has coordinated or participated on more than 30 environmental studies in both the private and public sector. He is member of the CONACyt Network on Socio-ecosystems and Sustainability (Red CONACyT de Soci-ecosistemas y Sustentabilidad (RedSocioEcoS).

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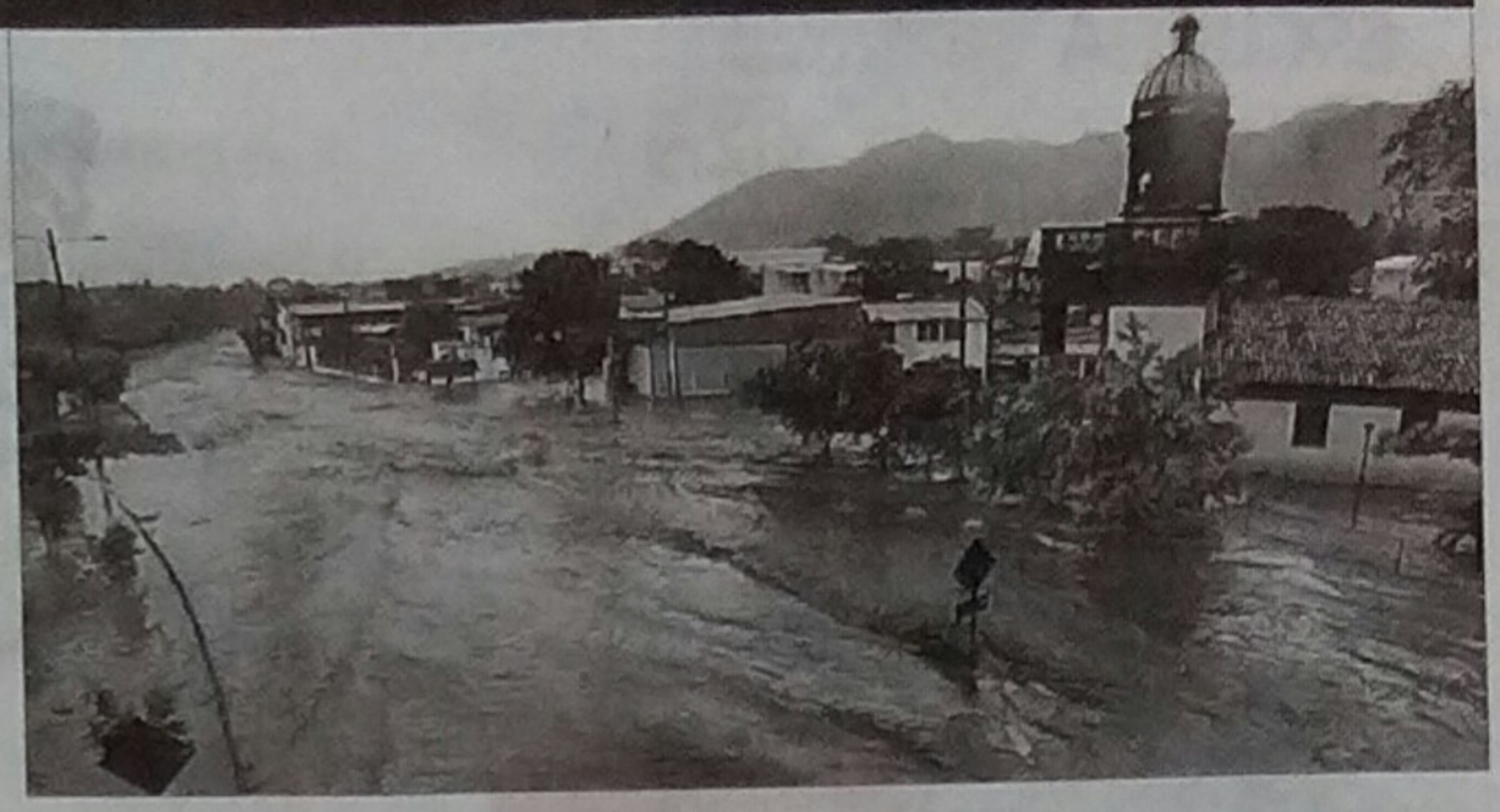
Coordinadora: Celia Gayosso
culturadx@hotmail.com
Tel: 818 30 00 Ext. 116

Integridad ecosistémica y congruencia en las políticas de desarrollo



Dos temas para reflexionar en el Día Mundial del Medio Ambiente

El próximo miércoles a las 18 horas, se realizará el conversatorio *Qué le pasa al Planeta*

POR MIGUEL EQUIHUA, OCTAVIO PÉREZ-MAQUEO, GRISELDA BENÍTEZ, CARMEN MAGANDA[1] Y HARLAN KOFF[2]

México, como muchos países del mundo, necesita enfrentar los retos ambientales y sociales actuales y adoptar modalidades de desarrollo con objetivos sostenibles y equitativos. Tal agenda, que pone al ambiente y a las personas en el foco del desarrollo humano, clama proactividad y compromisos tanto a nivel local y de los países como en el conjunto de las naciones. En 2012 las Naciones Unidas emitió un posicionamiento en relación con "El futuro que queremos" y destacó, entre otras cosas que: "Requerimos enfoques holísticos e integrados para el desarrollo sostenible que sean capaces de guiar a la humanidad a vivir en armonía con la naturaleza y liderar esfuerzos para restaurar la salud y la integridad de los ecosistemas de la Tierra."

En línea con esta forma de pensar y la visión que está surgiendo de tales planteamientos, se ha conformado la agenda 2030 emitida por las Naciones Unidas el primero de febrero 2016. Sobre todo, esta agenda cambió los objetivos del marco mundial de desarrollo anteriormente basados en indicadores (cuantitativos), hacia una aproximación basada en estrategias transformadoras que reconocen los vínculos entre las políticas de desarrollo y otras políticas públicas. Con esta acción, este programa ha incorporado una visión más compleja y multidimensional del desarrollo sostenible plasmada en los llamados Objetivos del Desarrollo Sustentable que los países miembros han acordado adoptar.

De hecho, la problemática ambiental tiene muchos frentes, desde luego uno muy visible es el cambio climático, pero otros también graves reciben mucho menos atención en los medios masivos de comunicación. Es el caso de la pérdida de la biodiversidad o la transformación acelerada de los ecosistemas para dedicarlos a otros usos de interés humano. Desde luego, es inevitable modificar espacios naturales para convertirlos en áreas de producción de bienes de valor para nuestras economías. Sin embargo, nuestra creciente comprensión de los vínculos que guardan las economías y el bienestar de los seres humanos, con la condición que guardan los ecosistemas a nuestro derredor, nos impulsan a buscar formas más inteligentes de producir lo que necesitamos sin dañar absurdamente a la naturaleza. En esta línea, organizaciones internacionales como las Naciones Unidas, la Organización para la Cooperación y el Desarrollo Económico (OCDE) y la Unión Europea (UE), han señalado la urgencia de una mejor implementación y coherencia de las políticas públicas para el desarrollo (CPD), que es una herramienta política destinada a promover economías cuya producción apoye la sostenibilidad y la equidad. La posibilidad de hacer esto va de la mano con la apreciación de que es importante mantener la integridad de los ecosistemas. Esta apreciación ha sido manifestada tanto dentro del contexto científico, como en otras formas de conocimientos (indígena, ancestral o local). El interés común en cada una de ellas es mantener a los ecosistemas en una condición tal que puedan funcionar por sí mismos lo más posible, es decir sin depender de acciones de reconstrucción por parte de los seres humanos.

Resultados preliminares del análisis realizado para México, permiten reconocer que hay importantes espacios geográficos con baja integridad ecosistémica. Tal es el caso de Veracruz, que como ya se ha reportado, es un estado que resiente la alteración de su vegetación original en más del 80 por ciento de su territorio. Aunque tal modificación ecosistémica supone un incremento inmediato en los beneficios (alimentos, ganadería, agricultura), también implica una merma en la capacidad de los ecosistemas para responder a las tensiones que impone el cambio climático, por ejemplo.

En México estamos trabajando con bastante éxito en generar indicadores para medir la integridad de los ecosistemas. Estimamos que es posible contar con herramientas que midan con cierta exactitud esta integridad, de acuerdo desde luego con la variada naturaleza de los ecosistemas. También estimamos posible seguir en el tiempo el cambio que ocurra en dicha condición. Lo interesante de esto es que estamos acercándonos a tener herramientas que nos ayuden a valorar, en conjunto, el cambio ambiental que se manifiesta en la alteración de la salud de los ecosistemas. Estas herramientas innovadoras tienen un significativo potencial para nutrir de información y generar nuevas estrategias de desarrollo destinadas a promover la integridad de los ecosistemas, a través de políticas de desarrollo y la coherencia de las políticas públicas para el desarrollo.

Hay que ser conscientes de que estos cambios no ocurrirán sin la necesaria interacción de los actores sociales entre sí y con las instituciones en donde se manifiestan los múltiples y, frecuentemente divergentes, intereses sectoriales. Es en este contexto en donde se definen y operan las políticas públicas a las que nos referimos. Por lo que es solo así que podremos aspirar al cambio proactivo e informado en relación con la equidad y la integridad ecosistémica.

Estamos, pues, ante una interesante encrucijada para avanzar hacia la sustentabilidad en la que debemos encontrar formas de convertir nuestros avances científicos en insumos valiosos para diseñar nuevas políticas públicas, en tono con las aspiraciones globales manifiestas en acuerdos mundiales como las metas de sustentabilidad de las Naciones Unidas. México ha sido bastante hábil para idear instrumentos regulatorios novedosos, no lo ha sido todavía tanto en la calidad de su implementación. Por eso, debemos ser ambiciosos al diseñar nuevos instrumentos que incorporen los avances científicos para estimar la integridad ecosistémica e implementarlos en políticas públicas innovadoras.

Vemos con claridad que existe el potencial de aprovechar las capacidades técnicas existentes actualmente (satélites, sensores, capacidad de cómputo y almacenamiento masivo de datos por ejemplo), los avances científicos sobre procesamiento de datos y comprensión de los procesos ecológicos (métodos de análisis de grandes volúmenes de datos, modelación matemática y descubrimiento de patrones que definen la condición de los ecosistemas) y el conocimiento sobre los procesos sociales que hacen posible y ventajoso el diseño y adopción de instrumentos de política que den coherencia al desarrollo (apropiación de las prioridades del desarrollo, focalización en el logro de resultados, cooperación para el desarrollo y transparencia). Con estos elementos podemos abordar el gran desafío que tenemos delante: México necesita valorar la salud de sus ecosistemas para manejarlos y conservarlos sabiamente, debemos hacer esto en coordinación con una sociedad consciente y oportunamente informada. Si logramos hacer esto, México podría ser un líder ejemplar en las políticas globales de desarrollo sostenible.

Les invitamos el próximo miércoles 15 a las 18 horas al conversatorio *Qué le pasa al Planeta*, que se llevará a cabo en la Galería de Arte Contemporáneo, ubicada en Xalapeños Ilustres 135, en el marco de la celebración Junio, mes del ambiente.

1 Instituto de Ecología, AC (Inecol).
2 Universidad de Luxemburgo.