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Building a global framework for green growth based on comparative assessments of green growth indices and

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Building a global framework for green growth based on comparative assessments of green growth indices and expert opinions of policy makers

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1 Introduction

Green growth as a pathway to sustainable development is increasingly recognised and pursued by policy makers (ESMAP, 2012; The World Bank, 2012; OECD, 2014; Bi, Xiao and Sun, 2018; Godoy, 2018). Despite being a widely used concept, there is no globally accepted definition of green growth (Allen and Clouth, 2012; Jacobs, 2012; OECD, 2012; Schmalensee, 2012; GGKP, 2013; Bowen, Duffy and Fankhauser, 2016), resulting in development of a wide number of different frameworks. A similar concept, so-called green economy, which has its origin in different organisations and for different target groups, is used almost interchangeably with green growth (Kasztelan, 2017). Given the similarities in these concepts, literature on green economy is also used in this paper and referred to as *related (green growth) concepts*. Among the international organisations (IOs) which pioneered green growth concepts include the Organisation for Economic Co-operation and Development (OECD, 2011), the World Bank (Hallegatte *et al.*, 2011), the Global Green Growth Institute (GGGI) (as cited in Kasztelan, 2017) and United Nations Economic and Social Commission for Asia and the Pacific (ESCAP, 2013) and those developing related concepts include UN Environment (UNEP, 2011), United Nations Conference on Trade and Development (UNCTAD, 2011), United Nations Department of Economic and Social Affairs (UNDESA) (Allen and Clouth, 2012) and the Green Economy Coalition (GEC, 2012). UNDESA's "Guidebook to Green Economy" identifies as many as 13 different green growth-related definitions designed by IOs (Allen and Clouth, 2012). The Green Economy Coalition highlights the need for increasing the quality of life within the ecological limits of the planet in order to reach an inclusive green economy (GEC, 2012). UNCTAD puts emphasis on future generations and their right to live in an environment safe from environmental risks and ecological scarcities (UNCTAD, 2011). UN Environment's definition of green economy emphasises improvement of human well-being and equality while protecting the environment (UNEP, 2011). The World Bank defines green growth as a change in the development paradigm which requires switching from the traditional growth model into one which is resource-efficient, cleaner, and more resilient but not weaker (Hallegatte *et al.*, 2011). The OECD places emphasis on enhancing economic development without abating the environmental effectiveness in providing resources, which are essential for ensuring human well-being (OECD, 2011).

In 2012, GGGI together with OECD, UN Environment, UNIDO and the World Bank established the Green Growth Knowledge Platform (GGKP) to identify and address significant "knowledge gaps in green growth theory and practice"[3]. These gaps are attributed to the complex nature and multi-dimensional aspects of green growth (Jacobs, 2012; Ahlert *et al.*, 2013; GGKP, 2013, 2016; Bowen, Duffy and Fankhauser, 2016). To date, comparative measurement of green growth performance across countries remains a challenge due to lack of not only broadly understood concept of green growth, but also globally available indicators to operationalise this concept (Hirschnitz-Garbers and Srebotnjak, 2012; GGKP, 2016; OECD, 2017; Yang, Wu and Dang, 2017). Since 2017, GGGI through its Green Growth Performance Measurement (GGPM) Program has initiated further steps to address this challenge by improving green growth framework and application in close collaboration with large number of IOs and active consultation with policy makers and other stakeholders in different regions. The initiatives aim to enhance policy relevance of the concept of green growth by integrating experts' preferences and priorities as well as creating a platform for its transparent development. Policy relevance can be enhanced not only by making relevant information available (i.e., through research) but also aligning it to policy needs (Wolf, 2014; Oliver, Dickson, & Bangpan, 2015; Toffel, 2016).

[3] (http://www.greengrowthknowledge.org)

The GGPM Program follows two complementary strategies to enhance practical utility of the GGGI's concept of green growth in policy decision making – a stepwise scientific approach and a consultative process involving experts and stakeholders. The former involves rigorous research to understand the complexity and multi-dimensionality of green growth, while the latter entails consultations to understand the national and regional contexts that influence green growth policies. The GGPM Program uses the concept of green growth in framing the development of GGGI's Green Growth Index and Simulation Tool, which together support an integrated assessment of green growth policies and their impacts on green growth performance. The Index measures country-level performance based on a common set of metrics in five green growth dimensions—resource efficiency, natural capital protection, resilience to risks, green economic opportunities, and social inclusion—and across six thematic areas—energy, industry, transport, cities, agriculture, and forests. The Simulation Tool allows users to enhance their knowledge on how countries' green growth performance can be influenced by exploring the possible outcomes of implementing different policy options within these dimensions and thematic areas. The Green Growth Index and Simulation Tool are integrated methods and so the validity of the underlying models and assumptions of the latter depend on the policy relevance of indicators that frame the former. Nevertheless, this paper only discusses the green growth concept for GGGI's Index and Tool, and hence its focus is conceptual rather than empirical.

Specifically, this paper presents the scientific approach and consultative process for improving GGPM's conceptual framework for developing its Green Growth Index and Simulation Tool. The GGPM followed two levels of consultative process – at the international and regional levels. This paper focuses on the results of regional consultative process, hence the reference to "regional experts" in the discussion of results. Using these results, the paper aims to highlight opportunities for collaborative approaches among IOs to build a global framework for green growth index, the challenges in implementing a policy-relevant concept due to indicator and data gaps, and the reasons for diversity in conceptualising green growth across regions. The results presented in this paper will be used to finalise GGPM's green growth framework as applied through the Green Growth Index and Simulation Tool and identify areas for collaboration with other experts working on similar initiatives. Specifically, the comparative assessments of concepts of green growth will make it possible to identify gaps in the frameworks not only for GGGI but also for other IOs, and thus also identify opportunities for collaboration among institutional partners to further develop the global concept of green growth. The rest of the paper is structured as follows: Section 2 introduces the framework of Green Growth Index developed through the GGPM project; Section 3 discusses the methods for assessing most relevant global green growth indices as well as experts' opinions on indicators that frame the green growth concept; Section 4 presents the results of the assessments including the overlaps and diversities on existing green growth frameworks, ratings on policy relevance of the green growth indicators, and weights for policy priorities in the green growth framework; and finally, Section 4 concludes the paper with some recommendations on addressing indicator and data gaps and improving strategic global collaboration.

2 GGPM's framework of green growth

"Green growth is a development approach that seeks to deliver economic growth that is both environmentally sustainable and socially inclusive. It seeks opportunities for economic growth that are low-carbon and climate resilient, prevent or remediate pollution, maintain healthy and productive ecosystems, and create green jobs, reduce poverty and enhance social inclusion." (GGGI Refreshed Strategic Plan 2015-2020, GGGI 2017: p. 12).

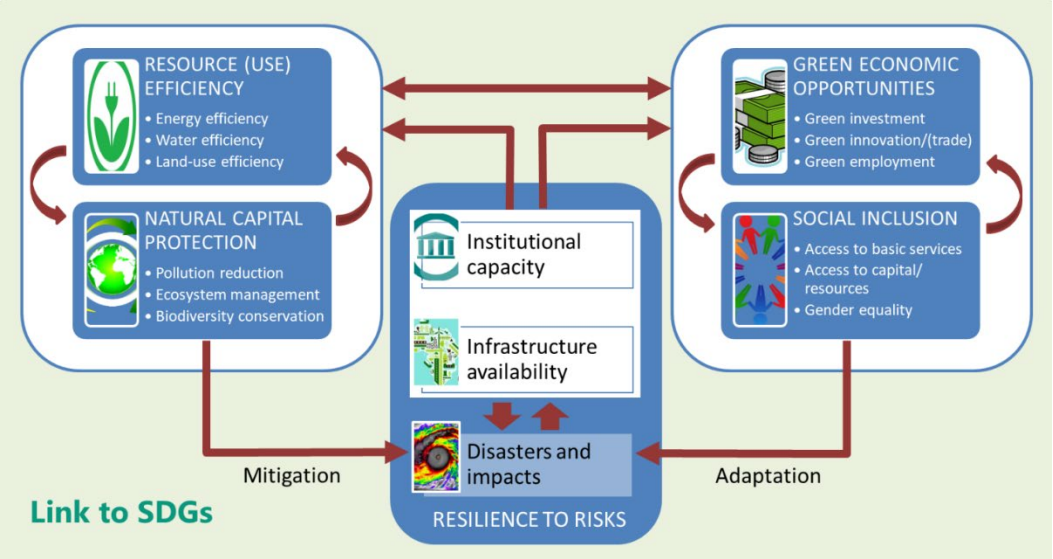
The GGPM's conceptual framework for its Green Growth Index builds on the GGGI's above definition of green growth. This definition is consistent with the GGKP's notion of green growth (GGKP, 2013, 2016), which emphasises five main themes of relevance for measuring inclusive green growth including resource efficiency and decoupling, natural assets, risks and resilience, economic opportunities, and inclusiveness. A sustainable environment can be achieved through efficient use of resources and protection of natural capital, while social inclusion can be enhanced through creation of green economic opportunities for different sectors of the economy and different segments of society. Environmentally sustainable and socially inclusive growth will help create a low-carbon economy and climate resilient society, and vice versa.

GGPM uses the five themes to represent the five dimensions of the Green Growth Index (Figure 1). Resource efficiency (i.e., on both production and consumption sides) is an essential component of green growth as it accounts not only for the quantity of resources being consumed, but also how efficiently they are being consumed. Resource depletion is a major concern for the long-term sustainability of societies as many economic activities rely on them. Natural capital protection refers to efforts to maintain the environment and ecosystems in good health to support and allow life to thrive. Both dimensions of resource efficiency and natural capital protection represent efforts to enhance environmental sustainability. Green economic opportunities monitor the shift of societies to create and foster more sustainable economic activities and employment which have positive rather than negative environmental impacts. The social inclusion dimension evaluates how all members of society gain access to these new opportunities and take part in social growth. Both dimensions of green economic opportunities and social inclusion represent efforts for socio-economic development.

The resilience dimension measures the ability of governments and other parts of society to prevent, prepare, recover, and adapt to climatic and other environmental risks. Resilience to risks is a central theme for green growth because it is closely interlinked to other green growth dimensions. For example, addressing the nexus of resilience and resource efficiency in urban areas has the potential to generate social, economic, and environmental returns far beyond those which could be achieved by addressing these agendas separately (Dodman, Diep and Colenbrander, 2017). With enhanced resilience, natural capital itself becomes more resilient, resistant, and adaptable to change (e.g., resilient to exploitation or degradation), can continue to provide ecosystem services and in some cases enhance those services, and can be further transformed in beneficial ways (Guerry *et al.*, 2015). Similarly, enhancing society's resilience will only be possible by maintaining and enhancing ecosystem resilience as social, economic, and ecological sustainability are interdependent (EEA, 2015). Institutions and infrastructure enhance resilience not only through pre-disaster mitigation and post-disaster adaptation, but also by creating an enabling environment for resource efficiency (USAID, 2018), natural capital protection (Amjad *et al.*, 2015), green economic opportunities (The Energy and Environment Council Government of Japan, 2012), and social inclusion (UNICEF, 2016). From an institutional perspective, an enabling environment relates to competence on political

leadership, capacity to implement policies and regulations, facilitation of stakeholders' participation, etc. (GGBP, 2014; Fioramonti and Kononykhina, 2015).

Figure 1 GGPM's conceptual framework for the Green Growth Index

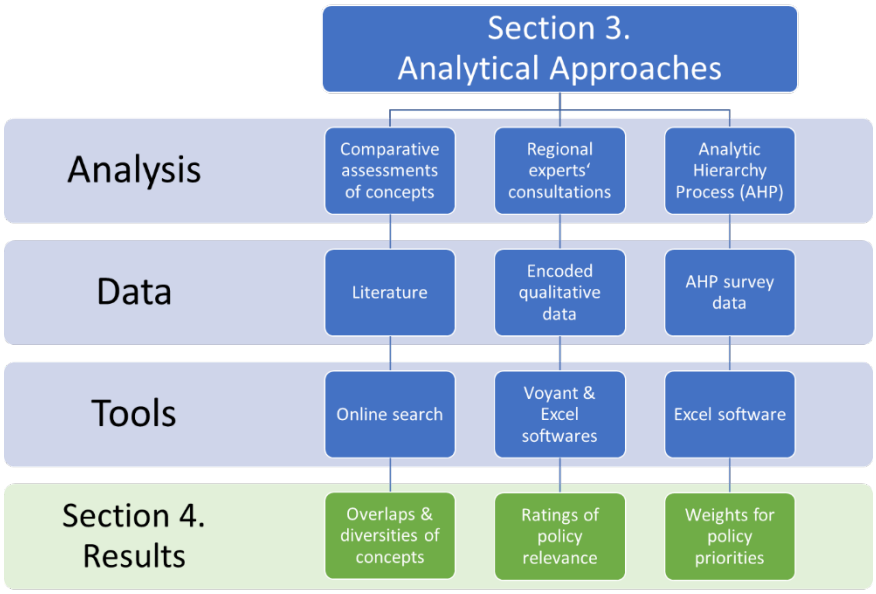


The indicators that are used to frame the GGPM green growth concept are grouped into three categories in each dimension (Figure 1). The list of indicators included in the GGGI's Green Growth Index are presented in Appendix 1. The selection of indicators for each dimension and category was supported by comprehensive literature review. Details are provided in a separate report (Acosta et al. 2019).

3 Analytical approaches

GGPM conducted three types of analyses to assess the overlaps and diversities of existing global green growth concepts as well as experts' opinions on the ratings of policy relevance and weights for policy priorities of green growth indicators (Figure 2). These include comparative assessments of green growth concepts, regional experts' consultations, and analytical hierarchy process (AHP). The objectives of the analyses as well as their data and tools are described below.

Figure 2 Analytical approaches for the concept of green growth



3.1 Comparative assessments of frameworks

The objective of this analysis is to understand similarities and differences in the major global and regional green growth indices. The foci of the analysis are the frameworks and design process for green growth concepts (Table 1). Brief description of the foci of the analysis, which were based on systematic guidance provided in literature, are discussed below.

Table 1 Foci of analysis of global green growth concepts

Thematic focus	**Foci of analysis**	**Guidance for analysis**	**Relevant literature**
Frameworks	Conceptual	Build a framework that clearly defines the phenomenon and its sub-components and weighs the latter according to their relative importance	Nardo et al. 2005
Design processes	Internal (or Inhouse)	Select indicators based on the principle of fitness-for-purpose	Nardo et al. 2005

	Consultative	Involve other stakeholders for the indicators for issue identification; develop a sound analytical design for the policy indicators	UN Environment 2014

Frameworks: The structure of the indicators needs to be selected carefully according to a given conceptual framework. The OECD Handbook emphasises that "*[t]he framework should clearly define the phenomenon to be measured and its sub-components, selecting individual indicators and weights that reflect their relative importance and the dimensions of the overall composite. This process should ideally be based on what is desirable to measure and not on which indicators are available*" (Nardo *et al.*, 2005). Moreover, the Handbook suggests to further divide multiple dimensions into several sub-groups, which should not be independent of each other, and existing linkages should be described theoretically or empirically to the greatest extent possible. The comparative assessment involved looking at the categories of the indicators and their linkages to the indicators and dimensions.

Design processes: The design processes focus on steps undertaken to develop and apply the framework (e.g., in the form of index and/or dashboards) and the range of institutions included in the development process. There are two general processes for designing green growth conceptual frameworks, based on the fitness-for-purpose principle and on stakeholder consultations. The OECD Handbook suggests the adoption of a fitness-for-purpose principle when selecting indicators that aim to target end users' needs. Because it entails a process that is entirely internal to the organisations, developing the framework depends on a strong theoretical foundation, well-defined narrative, and scientifically driven set of indicators. UN Environment proposes the involvement of a broad set of stakeholders to support the design and implementation of a coherent and inclusive green economy strategy (UNEP, 2014). This is particularly relevant for conceptual frameworks that use cross-sectoral indicators and are based on policy-driven sets of indicators. The comparative assessment identified the process that was ultimately followed in developing the frameworks for green growth indices.

The green growth concepts included in the above-mentioned comparative assessment have been selected according to a set of criteria that ensure relevance and comparability with the GGGI measure. These are the multi-national scope, the structure (composite index or dashboard) and the frequency of updates (Galotto and Acosta 2019). The complete list of conceptual frameworks related to green growth is presented in Appendix 2, but only five of them met the criteria.

3.2 Regional expert consultations

To validate the policy relevance of the indicators to policy and to national and regional contexts, opinions were collected from expert participants in four regional consultation workshops which GGGI conducted between August and October 2018 (Table 2).

Table 2 Regional Consultation Workshops in 2018

Geographical coverage	Date	Location	Countries of the experts*	Number of experts**	
				Government	Others
Asia-Pacific	23-24 August	UN Conference	Thailand, Myanmar, Philippines,	15	5

		Center in Bangkok, Thailand	Cambodia, Laos, Papua New Guinea, China, Nepal, Vietnam, Mongolia, Vanuatu, Indonesia		
Middle East and North Africa (MENA)	16-17 September	Ministry of Climate Change and Environment in Dubai, UAE	UAE, Jordan	17	7
Africa	20-21 September	United Nations Conference Centre in Addis Ababa, Ethiopia	Ethiopia, Morocco, Mozambique, Uganda, Senegal, South Korea	15	7
Latin America and the Caribbean (LAC)	4-5 October	NH Hotel, Centro Historico, Mexico City, Mexico	Chile, Costa Rica, Peru, Guyana, St. Lucia, Paraguay, Mexico, Colombia	17	3
			TOTAL	**64**	**22**

*Experts in other countries were also invited but were not able to attend, i.e., 3 countries in Asia Pacific, 4 countries in MENA, 1 country each in Africa and LAC, and 5 GGGI Council Member countries.
**These numbers exclude the GGGI Country Officer and partners who supported the GGGI Headquarter Staff in organizing the regional workshops. The regional workshops were conducted in close collaboration with different organizations including the United Nations Economic and Social Commission for Asia and the Pacific in Bangkok, the Ministry of Climate Change and Environment in Dubai, and the Ministry of Environment in Mexico City. The workshops were supported by the GGGI Country Representatives and Officers in Bangkok, Dubai, Addis Ababa, and Mexico City, where the workshops were conducted.

Participants and organizers: The main participants of the regional workshops included government officials who are working on or have expertise in green growth issues. Other experts from IOs and research institutions that are supporting green growth knowledge generation, planning, policy development, and investment in GGGI member countries and partners also participated in the workshops. GGGI Country Representatives and country-based staff supported the workshops in Bangkok, Dubai, Addis Ababa, and Mexico City, where the workshops were conducted. There were 86 experts from 28 countries who participated in the workshops, about 74 percent of whom work in the public sector (Table 2). These numbers do not include the 17 GGGI staff, GGGI Country staff, and partners who supported the regional workshops. GGGI country staff and partners identified the experts in their respective countries and invited them to participate in the workshops. About 14 countries were not able to participate mainly due to the experts' busy schedule or other important government priorities at the time of the workshops.

Structure of the workshops: The two-day consultation workshops followed a similar format in each of the four regions, consisting of the following:

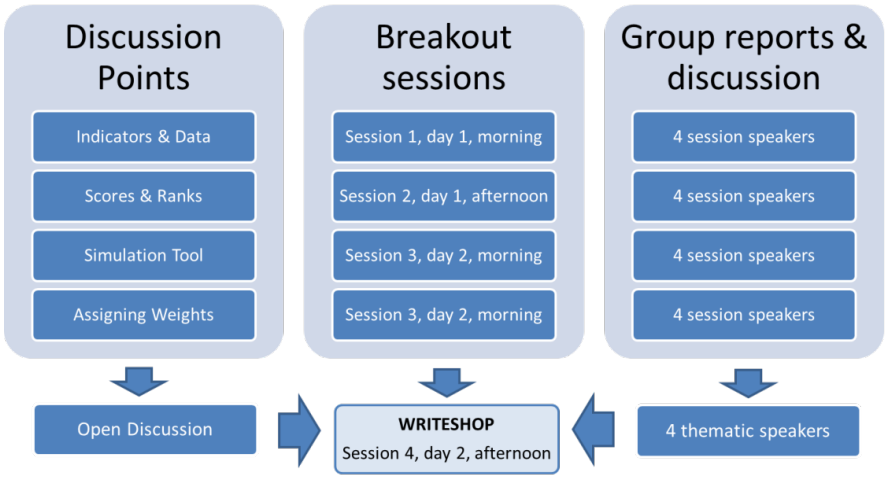
- Welcome remarks to emphasize the goal and importance of the workshop;
- Thematic presentations to inform experts on the concept and methods of GGGI's Green Growth Index;
- Breakout sessions for experts to discuss the questions raised during the presentations;
- Reporting and write-up sessions for experts to share their opinions on the questions given to the workshop participants; and
- Concluding remarks.

The presentations included details on the concept (i.e., dimensions, indicators, and data) and methods (i.e., outliers, normalization, aggregation, weights, etc.) of the Green Growth Index. A brief presentation and discussion on the Simulation Tool, which links the Green Growth Index to policy scenarios, was also part of the workshop. The workshops had four main parts including (Figure 3):

- Introduction of the discussion points, which were embedded in the thematic presentations;
- Breakout sessions where experts, in groups of about four, deliberated on the discussion points;
- Group reports and discussion where each group's speaker reported on the highlights of their discussion; and
- A "writeshop" where experts in each group wrote down details of their responses to the discussion points.

The time allocated to these parts varied across the regional workshops. In most cases, experts needed more time to discuss indicators and data as well as to write their group reports. The two-day workshops lasted from 9 a.m. to 5 p.m., except for the MENA regional workshop in Dubai which ended at about 2:30 p.m.

Figure 3 Structure of the regional experts' consultations



Breakout sessions: To allow for a good spread of experience, expertise, and knowledge in each group, experts from the same countries and organisations were requested to join in different groups. Whenever appropriate, gender balance was also used as a criterion in assigning experts into their groups. There were about 4-6 experts in each group. Five flip charts were used to hang information sheets on list of indicators and characteristics of data, with each flipchart representing each dimension of green growth. Each group took turns on each flip chart to discuss the information and write down answers to discussion points on sticky notes. The GGGI staff and partners guided the discussion and provided clarification to the questions raised by the experts during the breakout sessions. For the assessment of policy relevance of the

GGPM's framework for the Green Growth Index, the relevant discussion points during the breakout sessions include the following:

- How will you rate the level of importance of the indicators and data used in each indicator (i.e., "High", "Medium", "Low", "Not relevant")?
- Please provide a brief explanation of your answer. If your answer is "low" or "not relevant", please suggest more relevant indicators and data.

To allow quantitative analysis of the group's responses to above discussion points, the level of importance was encoded as follows: high = 5, medium = 3, low = 1, and not relevant = 0. Geometric mean was applied to the encoded data and to analyse responses at the regional level as well as overall ratings on the indicators. The ratings with values from zero to five were presented in gradient colours (also called heatmap). GGGI's GGPM team them used Excel software to encode and analyse data, and to create a heatmap. Moreover, to analyse the preferences of the regional experts, as well as the perceived gaps of the Green Growth Index, we used different text visualization and collocation tools available at Voyant Tools (Sinclair and Rockwell, 2016), which is an open-source web-based text analysis environment.

3.3 Analytical Hierarchy Process (AHP) survey

To collect opinions on the policy priorities for green growth, the experts were asked to assign weights to the indicators in each dimension using the analytic hierarchy process (AHP). AHP is a participatory and multicriteria decision-making approach that informs about the relative importance of indicators based on their pairwise comparisons (Dedeke, 2013; Pakkar, 2014). For example, for the resource efficiency dimension, experts were asked which they consider more important, energy efficiency or land-use efficiency. Then, they had to provide the level of importance of one indicator over the other as follows: 1 = equal importance, 2 = weak difference in importance, 3 = moderate importance, 4 = moderate plus, 5 = strong importance, 6 = strong plus, 7 = very strong importance, 8 = very, very strong importance, and 8 = extreme importance. Appendix 3 presents the structured questionnaire for the AHP. Except for the workshop in the MENA region, during the workshops each expert received the AHP questionnaire to provide individual weights for each indicator. For the MENA workshop, GGGI sent questionnaires to the experts by e-mail in December 2018.

GGGI used an AHP Excel Template developed by Goepel (2018) to analyse the responses of the experts from the questionnaire. It conducted additional analyses to assess the consistency of the opinions of the experts on ratings and weights. In addition to the weights, the AHP Excel template generates a consensus index that ranges from 0% (no consensus between experts) to 100% (full consensus between experts).

4 Results and discussion

4.1 Overlaps and diversities on green growth indices

GGGI considered other frameworks of green growth for the comparative assessments with the Green Growth Index and Simulation Tool. These include the Asian Development Bank's (ADB) Inclusive Green Growth Index (Jha, Sandhu and Wachirapunyanont, 2018), the African Development Bank's (AfDB) African Green Growth Index (AfDB, 2014), UN Environment's Green Economy Progress Index (UNEP, 2012), and the Dual Citizen Institute's (DCI) Global Green Economy Index (Tamanini *et al*., 2014). ADB's concept of green growth was designed to develop a regional index and measure green growth performance in developing countries in the Asia-Pacific region, but it can be applied in all countries and regional settings, and for all levels of development. The AfDB's concept of green growth was piloted to support its 2013-2022 Strategy, which focuses on inclusive growth and the transition to green growth across the Africa region. DCI's concept of green economy was also applied in a global index that is updated every two years. UN Environment's concept, which was developed to measure green economy progress, used a framework that combines a composite index and a dashboard of indicators. Finally, the OECD concept of green growth was designed only for dashboards (i.e., no composite index).

4.1.1 Frameworks

The structure of the indicators included in the green growth frameworks of the above-mentioned IOs is presented in Appendix 1. The indicators in the ADB and UN Environment's frameworks are grouped according to a three-pillar structure representing economic development, environmental sustainability, and social inclusion. In addition to the three pillars of sustainability, GGGI's and AfDB's frameworks also include indicators related to institutions. DCI's framework has indicators for environment, the economy, and institutions, but none addressing social aspects.

The GGGI's framework is structured into five dimensions, where two out of five represent the environmental pillar, i.e., resource efficiency and natural capital protection. These two separate dimensions on environment emphasise the different pathways to achieve green growth – efficiency and protection, which require different policy strategies. The "green" aspects of growth are also reflected in the economic dimension (i.e., green economic opportunities) with indicator categories referring to green investment, green innovation, and green employment. The green economic opportunities are expected to not only support resource efficiency and natural capital protection but also enhance social inclusion. An important dimension that is unique to GGGI's framework is resilience to risks, which is framed to have interlinkages with the other dimensions. The choice and structure of the indicators can be clearly reflected from GGGI's definition of green growth as presented in section 2 of this paper. The GGGI framework has a total of 36 indicators that capture the multiple dimensions of green growth.

UN Environment's Green Economy Progress Measurement framework includes 13 indicators that are linked with the three challenges given in its definition of green growth: "*An Inclusive Green Economy is a pathway designed to address three main global challenges, namely: (a) persistent poverty; (b) overstepped planetary boundaries; and (c) inequitable sharing of growing prosperity*" (PAGE 2017: p.3). The narrative proposed by UN Environment suggests that the progress achieved in the social, environmental, and economic indicators promotes the creation of a new generation of capital (natural, physical, human and social) which will serve as input in the production of environmentally friendly goods and services (through consumption, investment,

trade and public spending). The indicators are intended to capture the multi-dimensionality of green growth. However, unlike the GGGI's framework, the indicators are not grouped into dimensions or sub-categories. As in GGGI's framework, the economic pillar also includes green indicators such as green trade and environmental patents. Although many of the UN Environment's indicators are included in the GGGI's framework, the concepts behind their frameworks are different – UN Environment deals with progress and GGGI with performance.

ADB's framework has a total of 28 indicators that are organised into three pillars – 7 for environmental sustainability, 14 for social equity, and 7 for economic growth. ADB's definition of green growth is more straightforward than GGGI's and UN Environment's definitions: *"The IGGI (Inclusive Green Growth Indicator) was designed to measure progress on inclusive and environmentally sustainable growth at the national level"* (Jha et al. 2018: p.20). The three pillars are assumed to be supportive of green growth independently as there are no defined interlinkages between them. There are few overlaps in the environmental and social indicators in the frameworks of GGGI and ADB, but none in terms of economic indicators. ADB's economic indicators are mainly related to overall economic growth. Thus, unlike GGGI and UN Environment, the economic pillar in ADB's framework does not strongly emphasise "green" aspects of growth.

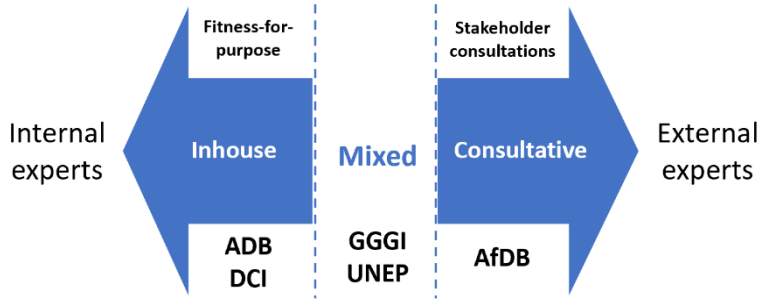
AfDB's framework includes five dimensions: socio-economic context and characteristics of growth, environmental and resource productivity, monitoring the natural asset base, gender, and governance. There are 48 indicators which are grouped unequally among the dimensions, with socio-economic context and characteristics of growth having largest number of indicators. Because the economic and social are integrated in one dimension, it was not intended to include "green" aspects of economic growth. The choice of the dimensions or structure of the indicators are not reflected from the AfDB's definition of green growth: *"the promotion and maximization of opportunities from economic growth through building resilience, managing natural assets efficiently and sustainably, including enhancing agricultural productivity, and promoting sustainable infrastructure"* (AfDB 2014: p.1). Like GGGI, AfDB's framework has a dimension related to institutions. However, the institutional indicators in the two frameworks are very different: AfDB focuses on governance issues that hinder green growth in Africa, while GGGI emphasises institutions that can enhance resilience to risks.

Finally, DCI's framework is structured in four dimensions: leadership and climate change; efficiency sectors; market and investment; and environment. It has a peculiar structure that departs from the classic green growth narratives, in particular by excluding social inclusion indicators. When DCI first published its Global Green Economy Index in 2010, it did not explicitly offer a definition of green growth or any concept to inform about the choices of indicators. Only in its Report in 2014, an explanation was provided on what guided the DCI's framework: "*We first published the Global Green Economy Index in 2010 guided by a belief that the environment, climate change and green, low carbon growth would rapidly become defining issues for national policy makers and the global reputation of countries.*" (Tamanini et al. 2014: p.5). The latter part of this definition somehow reflects the indicators chosen for the dimension on leadership and climate change, for example, media coverage and climate change performance. Like GGGI and UN Environment, the economic dimension considers the "green" aspects of economic growth.

4.1.2 Design processes

The design processes used by the IOs in building green growth concepts and their application are relatively diverse, with ADB and DCI using in-house processes, AfDB using consultative processes, and the GGGI and UN Environment (or UNEP) using a combination (Figure 4).

Figure 4 Design process used by international organisations



While both GGGI and UN Environment adopted a mixed process, the former put more emphasis on the consultative process and the latter on defining the principles of green economy. As mentioned in the introduction of this paper, GGGI followed two complementary strategies to enhance policy relevance of its Green Growth Index – a stepwise scientific approach and a consultative process with experts. GGGI's index is a result of a long consultation process, which started in the development of a pilot version in 2016. The consultation process aimed at validating the choice of indicators, which were initially identified from systematic literature review of green growth related theories and case studies. In particular, the involvement of external experts in designing the GGGI's green growth framework was significantly expanded in 2018, with participation of over 100 experts from IOs as well as government agencies, non-government organisations and academic institutions. Moreover, by forming an international expert group for the Green Growth Index, GGGI made collaboration with other IOs with expertise on developing green growth concepts such as the UN Environment, the OECD, the WB, the International Labour Organization (ILO), the United Nations Industrial Development Organization (UNIDO), the United Nations Development Programme (UNDP), UN Conference on Trade and Development (UNCTAD), the Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), etc. as an integral part of its design process.

In a different yet comparable way to GGGI, UN Environment's framework and its applications are the outcome of an intense theoretical and methodological effort from experts within UN Environment and from academia, which resulted in a relatively complex index design. The selection of indicators and methods for aggregation are based on analytical assumptions. However, before finalising the index UN Environment did conduct some consultations. The report itself is published as part of the Partnership for Action on Green Economy (PAGE) – a joint initiative by the UN Environment, the ILO, the UNDP, the UNIDO and the United Nations Institute for Training and Research. Moreover, a wide group of experts including the Green Growth Knowledge Platform Indicators and Metrics Working Group, the Organization for Economic Co-operation and Development, and other non-government organization representatives were invited to propose comments and suggestions during two workshops. Those were taken into account and, where appropriate, translated into structural modification and addition of indicators (PAGE, 2017).

AfDB followed a consultative process as shown in the launching of the pilot version of its index: "*Although simplicity is a key attribute in the development of green growth indicators, it must also be able to capture the imagination of users/stakeholders, in this case the African governments, development agencies (including banks), industry, labour and many others*" (Kararach *et al.*, 2018). AfDB's choice of indicators and weights for the indicators were very much dependent on the suggestions of a group of qualified experts and panellists. The weights were also intended to be further refined through a "*consultative process with various stakeholders to capture the diverse*

context and priorities among member states and sometimes applies advanced statistical methods" (Kararach *et al.*, 2018).

ADB's index followed an in-house process, where indicators were chosen by its internal expert economists. The methods are very rigorous and constructed based on a well-defined narrative. The ADB Report states clearly the principle followed for each step of the design process (Jha, Sandhu and Wachirapunyanont, 2018): the included variables were selected according to policy relevance, data availability, country coverage and access to data; equal weighting was chosen for its simplicity, transparency, and broad acceptance. More importantly, each procedural step was supported by a careful reporting of the scientific literature that were used to select the indicators. Similar to ADB, the DCI's index followed an entirely in-house process. The version proposed in the first edition was built by a group of internal experts and then constantly revised by adding new indicators, without involving external experts. But unlike ADB, DCI does not provide a detailed background description on its methods, which may imply the use experts' judgement without scientific support from the literature.

To sum up this section, among the different IOs, GGGI has arguably conducted the most wide-reaching consultations to date to ensure the policy relevance of the indicators included in its framework.

The next two sections provide highlights of the results from the regional consultations.

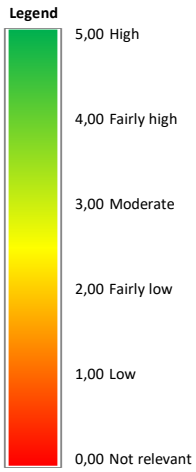
4.2 Ratings on policy relevance

Figure 5 presents the ratings of the regional experts on the indicators that were included in the GGGI's concept of green growth. Overall, the indicators are rated to be at least fairly high across regions except for the MENA region, which reflected slightly lower average ratings. The indicator that received high rating in all four regions was access to basic services. Other indicators that were rated high by experts in almost all regions included energy efficiency, pollution reduction, biodiversity conservation, and green investment.

African experts rated prevalence of undernourishment and access to clean fuels and technologies for cooking not relevant indicators. Two groups rated prevalence of undernourishment as not relevant for several reasons, including correlation with other indicators in access to resources and use of better indicators such as occurrence of droughts, hunger gaps, and access to technology and agricultural inputs. The same groups of experts provided similar suggestions for the clean fuels and technologies for cooking, i.e., correlation with other indicators in access to resources and use of better indicators such as availability of technology, access to and affordability of clean cooking stoves and the distinction between urban and rural data.

Figure 5 Experts' ratings on policy relevance of the indicators in the GGGI's green growth concept

Dimensions	Indicator Categories	Indicators	REGIONS			
			Asia Pacific	Africa	LAC	MENA*
Resource efficiency	Energy Efficiency	1. Final Energy Consumption/GDP				
		2. Electricity Transmission Losses				
	Water Efficiency	1. Percent Freshwater withdrawal				
		2. Irrigated cropping intensity				
	Land-Use Efficiency	1. Agricultural output per hectare				
		2. Crop diversification index				
Natural Capital Protection	Pollution Reduction	1. CO2 Emissions per GDP				
		2. Exposure to ambient PM2.5				
		3. DALY rate to ambient ozone				
		4. DALY rate due unsafe water				
	Ecosystem Management	1. Protected areas in marine areas				
		2. Change in Total Forest Cover				
		3. Level of soil threat				
		4. % natural resources depletion				
	Biodiversity Conservation	1. Red list index				
		2. Freshwater biodiversity in PAs				
		3. Terrestrial biodiversity in PAs				
Resilience to Risks	Institutional Capacity	1. Level government effectiveness				
		2. Gross capital formation growth				
		3. Online service index				
	Infrastructure Availability	1. Vehicles per 1000 inhabitants				
		2. Diversity of electricity mix				
		3. Mobile cellular subscriptions				
	Natural Disaster Impacts	1. Share to global disaster				
		2. Population affected by disaster				
Green Economic Opportunities	Green Investment	1. Renewable electricity output				
		2. Investment for adaptive actions				
	Green Innovation	1. Growth in Gross Value Added				
		2. Growth GDP/employed person				
	Green Employment	1. Growth in employment ratio				
		2. Growth in salaried workers				
Social Inclusion	Access to Basic Services	1. People access to drinking water				
		2. People access to sanitation				
		3. People access to electricity				
		4. Human capital index				
	Access to Capital Resources	1. Prevalence undernourishment				
		2. Access to clean cooking fuels				
		3. Inequality-adj. income index				
		4. Registering property				
	Gender Equality	1. Gender Inequality Index				
		2. Accessing institutions				
		3. % women in vulnerable jobs				



*For indicator categories only

In case of the LAC region, experts rated the percent of natural resources depletion, growth in Gross Value Added (GVA), and growth in Gross Domestic Product (GDP) per employed person as not relevant indicators. Although only one group rated these indicators as not relevant, other groups rated them low. The suggestion was to replace the first indicator with degradation and depletion costs. While these last two indicators were identified as relating more closely to growth than innovation, participants did not suggest alternative data.

The indicators that received fairly low ratings in the MENA region were natural disaster impacts and green innovation. The experts from Africa and LAC rated green employment indicators also fairly low. Like in Africa and LAC, green employment received the lowest rating in Asia Pacific in addition to institutional capacity. The results of the *Voyant* text analysis are discussed for each dimension below.

Resource use efficiency: The majority of the regional experts recognised the importance of energy, water, and land use efficiency in support of green growth development. The discussion, however, revealed that the national data to support the resource efficiency indicators need revisiting. For example, in Middle East countries such as the UAE, freshwater resources are fairly limited and the experts expressed that using freshwater data as a measure of the indicator may not show the real picture. In the UAE, for example, groundwater is the only source of natural freshwater, and, due to the lack of rainfall and elevated levels of evaporation, the rate of recharge is insignificant compared to the rate of abstraction from shallow groundwater aquifer systems (Al Blooshi et al., 2017). Accordingly, experts identified losses from water

distribution networks as an important measure to assess water efficiency as by doing so, it broadens the sector beyond agriculture. But data at the national level on water distribution network losses, quantity of treated seawater for desalination, and transboundary water flows may be significantly lacking for many countries. This represented an important data gap for some of the experts.

In terms of energy efficiency, regional experts suggested complementing the current measure with energy consumption per capita. In addition to energy intensity, experts explained that monitoring energy production and the energy source or carrier through data on energy supply and share of renewable energy reflect green growth principles better than assessing energy efficiency only from energy consumption. The gap on measuring renewable energy share shows that there are still possible data to consider improving the Green Growth Index.

In addition to monitoring land use for agriculture, data on urban land use can serve as a measure to show land use efficiency. This suggestion is consistent with what Zitti, Ferrara, Perini, Carlucci, and Salvati (2015: p. 3360) proposed in their study. According to this research, urban land use efficiency indicates how "[u]rbanization stimulates land use changes, determining the contraction of agricultural land, the consolidation of forests and other natural land and the expansion of urban land." Further, the discussions showed that material efficiency is an important category which could provide relevant information on resource efficiency.

Natural capital protection: The regional experts, in general, acknowledge that ecosystem management and biodiversity conservation are relevant indicators for natural capital protection. The measures supporting these indicators, however, need some review as data sources overlap and may induce a mis-estimation of the natural capital protection dimension. For example, by restricting the measure of protected areas to marine areas, the Green Growth Index will miss out on important terrestrial and freshwater protected areas. This, according to the regional experts, is a gap that needs to be addressed by expanding the protected areas measure to other ecosystems. Experts recommended a broad definition of protected areas, which can be both marine and terrestrial.

The experts from different regions expressed concerns on the quality and methodology of the data related to the soil measure, despite the fact that it had high reported relevance. While the soil threat index may be a viable measure, it only assesses the "level of risk on which the soil is exposed to degradation threats" and does not show the "ability of soil to perform ecosystem and social services" and respond to a "gradient of a stress or disturbance," which soil quality index and soil sustainability index measure, respectively (Tóth, 2008: p. 10). As such, the experts proposed to address this gap.

In support of pollution reduction, particularly air pollution, the regional experts noted that CO_2 is generally not considered an ambient air pollutant and recommended that it not be used as a measure for natural capital protection. CO_2 intensity, on the other hand, is relevant and may be more appropriate in the resource efficiency dimension. Other regional experts also raised the issue that PM2.5 or ambient ozone are not the emissions of highest concern relating to air pollution in some regions. As such, the air pollution measure should consider other pollutants such as volatile organic compounds (VOCs) or sulphur dioxide (SO_2). These preferences in terms of appropriate measures for air pollution are consistent with what many countries consider 'criteria air pollutants,' which include air pollutants that have been regulated and are used for the air pollution index in many countries (Wang, Ying, Hu, & Zhang, 2014). Carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ozone (O_3), and sulphur dioxide are among the 'criteria air pollutants' considered at the global scale. The regional experts suggested that a

similar review of the water pollution measures is necessary, highlighting the need for more recognized and systematic measures of pollution, including relating to hazardous materials.

Finally, regional experts expressed the need for a better understanding of the natural resource depletion measure. In addition to clarity in definition, they perceive that the adjusted savings from natural resource depletion may be a better indicator for the resource efficiency dimension. The experts from the LAC region suggested including measures on costs of degradation or depletion, as well as expenditure or budget dedicated to ecosystem protection and management.

Resilience to risks: Governments play critical roles in ensuring that communities at various levels of governance are resilient to several types of risks. While the regional experts agree about the significant role of governments to building resilience, they argued that the institutional capacity measure of government effectiveness is too limited and could be broadened. The regional experts showed interest in monitoring the institutional capacity of multiple stakeholders including the capacity and participation of civil society organizations and the private sector in decision-making. This is part of what Van der Vegt, Essens, Wahlstrom, & George (2015: p.976) refer to as "[t]ri-sector collaboration [which] is the coming together of public and private sectors with civil society to jointly address issues of relevance to society." As the researchers noted, "[t]he value of multi-stakeholder collaboration [to address resilience] has long been recognized" (Van der Vegt, Essens, Wahlstrom, & George, 2015: p. 976).

To further close the inclusivity gap under the institutional capacity dimension, the regional experts identified additional governance-related indicators such as rule of law, control of corruption, and human rights measures. Gross capital formation, on the other hand, may be a better measure for infrastructure availability or green investment according to the regional experts. Furthermore, the experts commented on the applicability of the online service index to measure public services as there is a wide disparity in terms of access to Internet in developed and developing countries. As such, the regional experts revealed the need to provide additional clarification of this measure as it does not clearly reflect institutional capacity, in general, or resilience, specifically.

The experts across all regions noted that the proportion of vehicles to population as a measure of resilience, in terms of having available transport in the event of evacuation, is problematic for two specific reasons. The first reason according to the experts is that this measure imposes a bias towards developed countries where cars a more widely used. Secondly, having more cars may translate to higher greenhouse gas emissions, which may contradict the principles of green growth and building resilience. To address these concerns, the regional experts suggested to replace the indicator with data on road infrastructure quality. Alternatively, the regional experts also suggested measuring the quantity or diversity of emergency response facilities and vehicles.

Similar to the proportion of vehicles as a measure supporting resilience to risks, the experts articulated the need to clarify how monitoring electricity diversity supports resilience to risks. They further expressed that the measure might be more appropriate under the resource efficiency dimension. The experts in different regions proposed that data on other forms of communication such as Internet and cellular coverage could be monitored to better assess infrastructure availability.

In terms of natural disaster impacts, all regions agreed to include the data on economic damage and losses from natural disasters. The regional experts, however, suggested to exclude the measure related to the share of global disasters, as only the impacts of and vulnerability to

disasters are actionable, not the occurrence of natural hazards, which depends on exposure. The experts also highlighted the importance of reporting on the implementation of disaster risk reduction plans and multi-hazard early warning systems.

Green economic opportunities: The regional experts exhibited a progressive stance and expressed their preference to include measures under the green economic opportunities dimension that focus on green or sustainable measures, rather than on general economic data that do not necessarily depict green growth performance. The experts acknowledged that green investments, green innovation, and green employment are good measures. However, the reliability of quality and comparable data may be an issue across different regions. Accordingly, the regional experts believe that this represents an important gap in measurement.

To monitor green investments, the experts argued that measuring it through the renewable energy output is limiting since there are other areas that mitigation investment is also pertinent, such as green bonds or investments in green public transport. Further, framing green investments through climate mitigation and adaptation lens is very restricting especially when green investments can take various forms according to Voica, Panait, and Radulescu (2015). The renewable energy is thus considered as insufficient proxy variable for green investments. As such, the regional experts suggested to revisit the measures and definition as well as identify data that can show growth in green investments at the most relevant levels of governance.

In a quantitative literature review, Schiederig, Tietze, and Herstatt (2011) noted that green innovation experts highlighted that green innovation does not necessarily refer to goods or services that reduce environmental burden but rather aim to increase environmental benefits. With this in mind, the feedback from the regional experts that the gross value added and real GDP growth per employed person may not be properly assessing green innovation as contextualized. Accordingly, to measure green technological innovation, the experts recommended that the number of green patents, copyrights, and trademarks may serve as proxy to green intellectual property rights, which the experts perceive as a better yardstick for real green innovation.

According to the majority of the regional experts, measures in support of green employment should, similar to green investment and green innovation, directly monitor green decent jobs, rather than account for growth employment figures in general. The experts highlighted the need for a clearer definition of green employment to measure it appropriately. The current suggested indicators for green employment are more suited to measure social inclusion according to the experts. This implies that the proxy variables (i.e. growth in employment, share of waged and salaried workers) are considered insufficient to measure “green” aspects of employment.

Social inclusion: Across all regions, experts noted that access to basic services and capital resources as well as gender equality are good but not sufficient indicators for social inclusion. To better measure gender equality or assess gender gaps, for instance, the regional experts believe that the data for the different dimensions of the Green Growth Index can be gender-disaggregated if data sources permit. This, according to the experts, is an important gap specifically for indicators under the green economic opportunities dimension such as decent green employment.

According to many of the experts consulted, while access to basic services such as water, electricity, and education are important measures, including access to affordable and nutritious food as well as access to basic healthcare services will add value to the indicator. Data such as life expectancy or child mortality would be an important indicator for access to basic healthcare services. The suggestion to include access to affordable and nutritious food as well as access

to basic healthcare services is consistent with Article 25 of the Universal Declaration of Human Rights, which states that "[e]veryone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services" (United Nations, 1948, p.7).

Regarding access to basic education, the experts expressed their interest in breaking down the indicator on education to monitor its different components such as literacy rates as well as the presence of green education programs. Concerning access to electricity, the experts noted the importance of reporting on access to sustainable and renewable energy. In considering access to sustainable and renewable energy, the regional experts cautioned about double counting as there are other dimensions of the Green Growth Index that assess renewable energy including access to clean fuels, which can possibly cover only those related to cooking. The experts also suggested adding a measure on access to financial services for monitoring access to capital. Further, the measure related to property registration, according to the regional experts, may not be an appropriate measure as access to property depends on each country's land ownership policy, while others noted the specific importance of monitoring indigenous communities' and women's property rights.

To further enhance the social inclusion dimension, the regional experts highlighted the interest in reporting results disaggregated not only be gender but if possible also by age and level of education. The experts also favoured monitoring social inclusion of different social groups within a population, such as indigenous people or people with disabilities. Some experts also suggested including data on community awareness and participation in public policymaking to this dimension.

4.3 Weights for policy priorities

There is an obvious divergence on opinions of the experts on how to assign weights on the indicators (Figure 6). The weights suggested for the indicators diverge most for the African region. The indicators of institutional capacity in dimension resilience to risks and access to basic services in dimension social inclusion received weights of 50 percent and above. These indicators were also rated "high" by the African experts in terms of policy relevance (Figure 5). In contrast, institutional capacity was considered only second most important in other regions with assigned weights of around 30 percent. Several articles in the literature suggest the importance of institutional capacity and access basic services in the African contexts. Pharoah (2016) and UNISDR (2011) emphasize the importance of strengthening capacity of government in not only delivering services, reducing risk, and building resilience, but also in building collaboration with NGOs, United Nations agencies, and civil society groups. In the African region, the supply and quality of basic services received affect human settlements and land development. In a study by the United Nations (n.d.), the households in this region have the least access to services like water, sewerage, electricity, and telephone compared with other regions such as the Asia-Pacific, the Arab States, and LAC. These conform to the relatively higher weights given to indicators for access to basic services in Africa as compared to the other regions (Figure 6).

For the Asia-Pacific region, access to capital resources received slightly higher weights than access to basic services. In this region, both access to basic services and access capital resources are critical in poverty reduction. For more effective delivery of services to the poor, attention must also be given to capital resources (ADB, 2004). Similarly, in LAC, both indicators are also critical in poverty reduction, but municipalities have fewer utilities to deliver these basic services (The World Bank, 2002). For the MENA region, experts weighted gender equality slightly higher than access to basic services. There is already meaningful progress in MENA

countries in gender equality in areas such as health and education. However, a report highlighted that one of the steps to further achieve gender equality in the region is to close the gender gaps in basic services (Habib et al., 2013).

Figure 6 Experts' weights assigned to the indicators in the GGGI's green growth concept

Like institutional capacity and access to basic services, the indicator of green investment in the green economic opportunities dimension also received higher weights in Africa region (over 50 percent). The weights for green investment are only less than 40 percent in other regions. The new United Nations Atlas shows that the Africa region's investments in renewable energy would help in establishing its economy (United Nations, 2017). The potential of renewable energy requires increased green investments from the private sectors. These investments need the power purchase agreements and reliable counterparties (Hajduka, 2017). Moreover, there are already programs and initiatives that promote green investment opportunities in the energy sector. These green investments aim to meet the goals of the Paris Agreement and Sustainable Development Goals (SDGs) (AfDB, 2018).

Except for natural capital protection, weights for the indicators in almost all dimensions also showed large divergence for LAC. Water efficiency in the resource efficiency dimension and infrastructure availability in the resilience to risks dimension turned out to have the highest weights in this region of at least 40 percent. Water efficiency in LAC has progressed over time. From just constructing large infrastructure for hydroelectricity generation and irrigation, efficient water management practices have expanded to drinking water, sanitation services, water conservation, and pollution control. Moreover, the region has recognized the significance of water sector for economic growth and poverty reduction (Canales & Jouravlev, 2012). Water efficiency only received second highest weights in other regions, except in MENA where it was given the same weights as energy efficiency.

Assigning high weights for infrastructure availability in LAC is relevant because, according to Fay and Morrison (2007), infrastructure is hampering the LAC region's capability to develop. Thus, the region needs to finance more infrastructure and the governments in the region should provide infrastructure service delivery. Infrastructure availability received different weights in the other regions, with the highest weight in the Asia-Pacific region (although not as much as other indicators), second highest weight in Africa (although not much higher than natural disaster impacts), and lowest weight in MENA. In the Asia-Pacific region, one of the identified commercial opportunities to strengthen resilience is to invest and develop infrastructure (ADB, 2013). In Africa, investment in infrastructure is also a priority to increase resilience to risk (Gallego-Lopez & Essex, 2016). In the MENA region, a 2013 report revealed that improved resilience to shocks and economic focus to resource efficient industries are more prioritized than building resilient infrastructure (Dimsdale & Mabey, 2018).

For the Asia-Pacific region, the weights assigned to the indicators by the experts are relatively close to each other in all dimensions, except for resource efficiency. The experts from this region assigned a weight of about 45 percent to energy efficiency, which is significantly higher than in other regions. Energy efficiency is considered as almost equally important as other indicators in MENA region and received lowest weights in the Africa and LAC regions. Energy efficiency activities in the LAC region have been limited and are typically only given priority in response to energy supply deficit and crises (Copenhagen Centre on Energy Efficiency, 2015). In the Africa region, inadequate access to energy services is a main challenge for development. Energy efficient technologies and renewable energy do not draw investment and policy commitment (UNIDO, 2009).

Another indicator that was assigned a relatively higher weight (40 percent) in the Asia-Pacific region as compared to other regions was pollution reduction. However, in LAC pollution reduction was considered as important as other indicators of natural capital protection, in MENA it had only the second highest weight, and in Africa it received the lowest weight at only 20 percent. Pollution rates are affected by factors such as industrialization, local climate,

economic development, and consumer behaviour. In the case of waste generation, a report by Hoornweg and Bhada-Tata (2012) revealed that the annual waste generation in East Asia and the Pacific is highest at around 270 million tonnes per year (i.e., as compared to Eastern and Central Asia with at least 93 million, LAC region with around 160 million tonnes, Africa and MENA with about 62 million tonnes each).

5 Policy implications and conclusions

5.1 Indicator and data gaps

The regional experts provided useful feedback on the conceptual framework for the GGGI's Green Growth Index. Many comments and suggestions also apply to the frameworks of other green growth related indices. Not only GGGI, but also other IOs can equally benefit from the assessments in this paper. According to the opinions of the regional experts, there are five main issues that need attention to enhance the policy relevance of the green growth frameworks: direct relationships of indicators to green growth; overlaps with other multi-dimensional concepts; diversity in institutional, economic, and environmental conditions; sufficiency in thematic dimensions; and quality of data and methodology.

Direct relationships of indicators to green growth

Many indicators for green economic opportunities in the GGGI's framework were considered to lack direct relationship to green growth. When data are not available, 'second-best' or 'proxy' indicators that measure the underlying relationships and have sufficient country coverage have to be used (Miola *et al.*, 2015). In the case of green economic opportunities, the experts commented that using proxy variables to represent or replace indicators with scarce data can result in bias towards specific group of countries and misinterpretation of green growth discourse. According to Saisana (2005), there is a danger to send misleading and non-robust policy messages if indicators in composite indices are poorly constructed or misinterpreted. The lack of definition for and distinction in "green" activities and outputs in economic activities cause uncertainty in the relevance of the indicators such as in green employment and green investment. To date, there are no data available globally to measure these indicators. The trade-offs of using proxy variables to replace lacking data, even temporarily (i.e. to be replaced as better become available), are thus very high particularly if the index is intended to guide policy. Like GGGI, most indicators for the economic pillar in ADB and AfDB's frameworks lack direct relationships to green growth.

Overlaps with other multi-dimensional concepts

For the dimension on resilience to risks, some experts suggested to include indicators on monitoring the institutional capacity of multiple stakeholders including the capacity and participation of civil society organisations and the private sector in decision-making. Others suggested indicators such as rule of law, control of corruption, and human rights measures. The suggestions are thus difficult to reconcile because the former refers to very specific and the latter more general indicators for institutional capacity. A commonality in both suggestions, however, is their reference to indicators of governance, which by itself is multi-dimensional. Integrating concept of governance in green growth will make the interpretability of the latter even more difficult. The complexity will be compounded by the ample critiques on the concepts of governance indicators including those from Worldwide Governance Index (Gregory, 2014; Schuman 2014) and Corruption Perception Index (Srinivasan, 2014; Heywood, 2016; Hough 2016). Other IOs that also used governance indicators in their green growth framework include AfDB and DCI. However, in contrast to the GGGI, which only used one indicator (i.e. government effectiveness) to avoid overemphasis on governance, the AfDB has four general governance indicators and DCI has three specific governance indicators. The DCI's indicators for governance are more oriented to green growth, i.e. Head of State's advocacy for green issues and Positive media coverage of national green economy. However, these indicators can be criticised in terms of data quality and methodology (see discussion below).

Diversity in institutional, economic, and environmental conditions

The experts' opinions on the relevance of the indicators tend to be influenced by their regions or countries' institutional, economic, and environmental conditions. Because these conditions are diverse across regions, indicators that are very important for some countries are considered irrelevant for the others. Examples are freshwater resources that are limited in supply in the Arab States, marine areas which do not exist for landlocked countries, PM2.5 which is not a concern in countries with small industry and transport, and online services which accessibility is limited by internet infrastructure. While these concerns are valid, excluding these indicators to compare green growth performance across countries in a global context will not be an appropriate solution. A global index should be able to capture policy concerns of global importance. The GGGI's framework of the Green Growth Index aims to represent multi-dimensionality of green growth to allow for comparative assessment across countries and regions. Other IOs that used similar indicators include UN Environment and ADB (i.e. PM2.5 for air pollution, freshwater withdrawal).

Coverage of thematic dimensions

The experts suggested to include indicators for material efficiency, which has not been sufficiently covered in the GGGI's framework. Given that material efficiency refers to "the pursuit of technical strategies, business models, consumer preferences, and policy instruments that would lead to a substantial reduction in the production of new materials required to deliver well-being," the material efficiency measure, to some extent, includes water and energy efficiency (Worrell, Allwood, & Gutowski, 2016: p. 575). This, accordingly, may fill some of the gaps identified for water and energy efficiency measures. The indicators that can be used for material efficiency are domestic material consumption and material footprint. The UN Environment's framework included an indicator for material footprint per capita. Like the GGGI, the green growth frameworks of other organisations did not include any indicators for material efficiency.

There were also suggestions to consider urban indicators for land use efficiency in the GGGI's framework. However, so far, no data are available to sufficiently measure urban land use efficiency for many countries. The definitions of urban areas are also diverse, with criteria ranging from political boundaries to population density, and some other countries also considering urban infrastructure (Mori and Christodoulou, 2012). Moreover, an accurate measurement of urban land use efficiency is difficult due to complexity of cities particularly in relation to the coexistence of economic, social, and environmental systems (Yang, Wu and Dang, 2017). Consequently, policy studies on urban land use efficiency are mostly country or local specific. Not only the GGGI, but also other IOs have no indicators for urban land use efficiency. However, to address the experts' comments, concerns in urban areas should be appropriately considered in other green growth dimensions (e.g. social inclusion).

Quality of data and methodology

Some experts expressed general concerns on using data produced and published by IOs. While some experts would prefer to use data from national statistical agencies, using data from IOs offers important advantages for measuring performance across countries. For example, collecting data from national agencies for more than 100 countries will be cumbersome; data from IOs are collected from national agencies and have undergone consistency checks. The United Nations (UN) coordinates statistical activities "to guarantee integrated systems of collection, processing and dissemination of data" (Eurostat, no date). The GGGI used data that are available online, except for vehicles per 1000 habitants and energy consumption, which

were bought from the data publisher (i.e. International Road Federation and International Energy Agency or IEA). The AfDB and ADB also used data from the IEA. Only the DCI used data that are not processed and disseminated through IOs such as Head of State's advocacy for green issues, Positive media coverage of national green economy, etc. Making the data and sources of data for the indicators transparent and available to experts and users will be useful in addressing the concerns on the quality of data and methodology for computing the data.

5.2 Potentials for strategic collaboration

The foregoing reveals that the different frameworks for developing green growth indices have their own strengths and weaknesses. One of the strengths is grouping the large number of indicators into dimensions. For complex concept, it is important to capture the nature of multidimensionality by increasing the range of indicators (Greco *et al.*, 2018). Except for the DCI, the dimensions for the green growth frameworks generally followed the three-pillar sustainability structure. Except for the economic pillar, there are also important overlaps in the indicators included in the dimensions of the GGGI, UN Environment, AfDB and ADB frameworks. There is thus a significant potential to re-align the green growth frameworks of these four IOs to develop a global index that is relevant not only across countries in a region but also across the regions. The popularity of using composite indices to measure complex phenomena continue to surge, with about 400 official indices for economic, political, social, or environmental measures and 100 indices for human progress (Greco et al. 2018).

To enhance the visibility, acceptability and importance of green growth index for policy amidst hundreds of other related indices, collaboration among GGGI, UN Environment, AfDB and ADB to develop either common or complementary frameworks for green growth index will be very useful. The GGGI has already taken initial steps to building strategic collaboration with other IOs. During one of the international experts' meetings organised by the GGGI in 2018, GGGI and UN Environment planned to collaborate to enhance the complementarity of their indices. During the GGGI's African Regional Consultation Workshop in Addis Ababa in 2018, GGGI and AfDB confirmed their collaboration to improve the African Green Growth Index based on the GGGI's framework. The collaborative project between them has been planned for 2019. While experts from the UN Environment participate in the GGPM's international expert group, those from the AfDB are regional expert reviewers for the GGGI's Green Growth Index. There are as yet no concrete plans for the collaboration between GGGI and ADB, but there is also potential to initiate similar activities due to important overlaps in both their conceptual frameworks.

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Appendix 1 Structure of the indicators in the different green growth and related indices

Environmental	Social	Economic	Others
Green Growth Index and Simulation Tool (GGGI)			
Resource efficiency 1.Energy efficiency 1.1 Total Final Energy Consumption/GDP 1.2 Transmission and Distribution Losses of Electricity (% of output) 2.Water efficiency 2.1 Freshwater withdrawal as a proportion of available freshwater resources 2.2 Irrigated cropping intensity 3.Land-use efficiency 3.1 Agricultural production per hectare 3.2 Crop diversification index **Natural Capital Protection** 1.Pollution reduction 1.1 CO2 per GDP, PM2.5 Exposure, and Ambient Ozone 1.2 DALY due to unsafe water sources 2. Ecosystem management 2.1 Coverage of protected areas in relation to marine areas 2.2 Change in forest cover 2.3 Soil threat index 2.4 Adjusted savings: natural resources depletion (% of GNI) 3. Biodiversity conservation 3.1 Red List Index 3.2 Proportion of important sites for freshwater biodiversity that are covered by protected areas	**Social inclusion** 1.Access to basic services 1.1 Population with access to drinking water 1.2 Population with access to sanitation 1.3 Population with access to electricity 1.4 Human capital index 2.Access to capital/resources 2.1 Prevalence of undernourishment (% of population) 2.2 Access to clean fuels and technologies for cooking (% of population) 2.3 Inequality-adjusted income index 2.4 Registering property 3. Gender equality 3.1 Gender Inequality Index 3.2 Accessing institutions 3.3 Vulnerable employment, female (% of female employment)	**Green economic opportunities** 1.Green Investment 1.1 Renewable electricity output (% of total electricity output) (Growth) 1.2 Economic readiness to leverage private and public sector investment for adaptive actions 2.Green Innovation 2.1 Growth GVA (Productivity) 2.2 Growth rate of real GDP per employed person 3.Green Employment 3.1 Employment (to population ratio, 15+, total) Growth 3.2 Wage and salaried workers, total (% of total employment)	**Resilience to risks** 1.Institutional capacity 1.1 Government Effectiveness 1.2 Gross capital formation growth 1.3 Online Service Index 2. Infrastructure availability 2.1 Passenger vehicles per 1000 inhabitants 2.2 Diversity of electricity mix (Herfindahl) 2.3 Mobile cellular subscriptions (per 100 people) 3.Natural disaster impacts 3.1 Share to global disaster 3.2 Total affected by disaster (Percent of population)

3.3 Proportion of important sites for terrestrial biodiversity that are covered by protected areas			
Green Economy Performance Index and Dashboards (UNEP)			
Environmental indicators 1.PM2.5 pollution mean annual exposure 2. Sum of terrestrial and marine protected area 3.Freshwater withdrawal 4.Share of land used for permanent crops 5.Ecological footprint 6. Emission of Nitrogen 7.Inclusive Wealth Index +	**Social Indicators** 1. Average of: Access to improved water sources, electricity, sanitation facilities 2. of Inequality in achievements between women and men across three dimensions: (a) reproductive health; (b) empowerment; and (c) the labour market 3. Palma ratio 4.Share of population above statutory pensionable age receiving an old age pension 5.Average number of years of education received by people ages 25 and older 6. Life expectancy at birth	**Resource efficiency/ economic indicators** 1. Export of environmental goods according to OECD and APEC 2. Patent publication in environmental technology by filing office 3.Share of renewable energy supply 4. Energy use per GDP 5. Material footprint per capita: Raw material consumption of used biotic and abiotic materials	
Inclusive Green Growth Index (ADB)			
Environmental Sustainability 1.Ratio of the sum of oil, natural gas, coal mineral, and forest rents to GDP 2.Annual availability of renewable water per capita 3.GDP per cubic meter of total freshwater withdrawal 4. Percentage of population exposed to air pollution levels exceeding WHO's 2.5 particulate air quality guideline 5.CO2 emissions relative to annual production 6.Energy intensity level of primary energy 7.Percentage of renewable energy consumption to total final energy consumption	**Social Equity** 1.Estimated percentage by ILO of employed to the population 2.Proportion of male and of female enrolled in primary education 3. Difference of the ILO- estimated male and female labour force participation rates 4. Number of years a new born infant would live if prevailing patterns of mortality at the time of their birth were to stay the same throughout their life 5.Number of infants dying before reaching 1 year per 1,000 live births 6.Percentage of population with access to improved sanitation 7.Percentage of population with access to improved drinking water 8.Percentage of population with access to electricity and non-solid fuel 9.Gini coefficient on inequality 10.Percentage of population living on less than $3.10 a day	**Economic growth** 1. Inverse coefficient of variation, real GDP per capita growth 2.Trade openness: Sum of exports and imports in percentage of GDP 3. HH Market Concentration Index 4. Percentage of people younger than 15 or older than 64 to the working-age population 5.Adjusted net savings 6. Gross general government debt	

	11.Average number of completed years of education of a country's population, 12. Percentage of total enrolment, to the population of the age group that officially corresponds to primary school 13.Political participation gap: difference of the proportion of seats held by male and by female in national legislatures		
African Green Growth Index (AfDB)			
Monitoring the natural asset base 1.Land, Forest, Agriculture 1.1 Arable and Cropland 1.2 Forest 1.3 Total protected area (marine and terrestrial) 2.Water 2.1Water efficiency 3. Disaster Risk 3.1 Total number of events 1900–2014 3.2 Total number of people affected 1900–2014 **Environmental and resource productivity** 1.Emissions 1.1 Production-based CO2 intensity 1.2 Production-based CO2 emission 2.Energy 2.1 Energy intensity 2.2 Share of renewable energy supply 2.3 Share of renewable electricity	**The socioeconomic context and characteristics of growth** 1.Demographics 1.1 Population density 1.2 Population, growth rate 1.3 Population, dependency ratio 1.4 % rural population 1.5 Employment creation 3. Health 3.1 Infant mortality 3.1 Life expectancy 3.3 HIV/AIDs prevalence 3.4 Hospital beds 3.5 Malnutrition prevalence 3.6 Health expenditure per capita 4. Education (4.1 Literacy rate (adult education) 4.2 Literacy rate (youth) 5 Poverty (5.1 Gini coefficient, 5.2 Population below $2) 6. Infrastructure and Access 6.1 Internet Access 6.2 Access to electricity (% of households with access) 6.3 Access to water (access to improved water source) 6.4 Access to improved sanitation facility)	**The socioeconomic context and characteristics of growth** 2. Economy 2.1 Real GDP, Agriculture, 2.2 Industry 2.3 Services sector, 2.4 GDP per capita 2.5 GDP growth rate 2.6 GDP purchasing power parity	**Governance** 1. Governance 1.1Political stability and absence of violence/terrorism 1.2 Government effectiveness 1.3 Regulatory quality 1.4 Rule of law 1.5 Control of corruption

	Gender 1. Gender 1.1 Prevalence of HIV (female) 1.2 Female adults with HIV 1.3 Labour force (female) 1.4 Literacy rate, adult (female) 1.5 Proportion of seats held by women in national parliaments 1.6 Proportion of women in ministerial level positions		
Global Green Economy Index (DCI)			
Environment 1 Population weighed exposure to fine particulate matter and percentage of the population burning solid fuel for cooking 2 Water: how well countries treat wastewater from households and industrial sources before releasing it back into the environment 3 Protection of terrestrial, marine areas and threatened species 4 Countries' fishing practices: use of heavy equipment and size of the catch 5 Loss in forest area from 2000 to present) **Efficiency Sector** 1 Building: LEED certification of commercial buildings 2 Emissions from transport and 10-year trend) 3 Renewable electricity as a percentage of national total 4 Tourism: Ranking of national tourism ministry efforts 5 Resource Efficiency: National recycling rates		**Market and Investments** 1 Country attractiveness for RE investment 2 Business climate for Cleantech innovation 3 Adoption of sustainability reporting by top 3 national companies (market capitalization) 4 National efforts to facilitate green investment	**Leadership and Climate Change** 1 Head of State's advocacy for green issues 2 Positive media coverage of national green economy 3 National positions & statements in international forums 4 Performance on climate change

Appendix 2 List of indices considered for the assessment

Type of Index	Index	Included or not and Reason
Composite Index	**Green Economy Progress (GEP) Index (UNEP)**	Included
	Yale Environmental Performance Index (Emerson et al., 2012)	Not Included. It only considers the environmental side
	WEF Sustainability-adjusted Global Competitiveness Index (Greenhill, 2011)	Not included. It estimates of the level of productivity and competitiveness of an economy, not the green growth
	Notre Dame Global Adaptation Index (ND-GAIN, 2013)	Not included.
	Global Green Economy Index (Dual Citizen LCC, 2014)	Included
	FEEM Sustainability Index (Eboli, 2011)	Not Included. They did not continue with updating the indicators.
	SOPAC Environmental Vulnerability Index (SOPAC, 2005)	Not Included. They did not continue with updating the indicators.
	OECD Better Life Index (OECD, 2013)	Not Included. They did not continue with updating the indicators.
	Ocean Health Index (Halpern et al., 2012)	Not included. Only considers (one specific) environmental side)
	Happy Planet Index (McGough, 2012)	Not included. It is more apt for measuring well-being rather than green growth.
	Climate Change Performance Index (Burck, Marten, & Bals, 2015)	Not Included. It only considers the environmental side
	Low-Carbon Competitiveness Index (Vivid Economics, 2013)	Not Included. They did not continue with updating the indicators.
	Earth Security Index (Earth Security Group, 2015)	Can be considered for inclusion.
	African Green Growth Index Africa Development Bank	Included

	Inclusive Green Growth Index Asian Development Bank	Included
Dashboard of Indicators	**OECD Green Growth Indicators (OECD, 2011b; 2014)**	Partially included.
	Eurostat Sustainable Development Indicators (Eurostat, 2014)	Not included.
Footprints	Global Ecological Footprint (Global Footprint Network, 2014)	Not Included.
	CO2 emissions embodied in international trade (OECD, 2015a)	Not Included.
	Global Resource Footprint (Tukker et al. 2014)	Not Included.
	Carbon footprint (UNEP, 2014)	Not Included.
	Water footprint (Hoekstra & Mekonnen, 2012)	Not Included.
Adjusted Measures	Inclusive wealth (UNEP, 2012)	Not Included.
	Index of Sustainable Economic Welfare (Daly & Cobb, 1989)	Not Included.
	Genuine Progress Indicator (Talberth, Cobb, & Slattery, 2007)	Not Included.
	Adjusted net savings (Hamilton & Clemens, 1999)	Not Included.
	Total wealth including produced and natural capital (World Bank, 2006, 2011)	Not Included.

Appendix 3 Questionnaire for the Analytical Hierarchy Process (AHP)

Name: _____

Organization: _____

Opinions on weights on indicators

Intensity of importance	Definition
1	**Equal importance**
2	Weak
3	**Moderate importance**
4	Moderate plus
5	**Strong importance**
6	Strong plus
7	**Very strong or demonstrated importance**
8	Very, very strong
9	**Extreme importance**

Resource efficiency

Question: Which is more important…?	Answer: a, b, or c	Give Intensity
(a) Energy Efficiency or (b) Water efficiency		
(a) Energy Efficiency or (c) Land-use efficiency		
(b) Water efficiency or (c) Land-use efficiency		

Natural capital protection

Question: Which is more important…?	Answer: a, b, or c	Give Intensity
(a) Pollution reduction or (b) Ecosystem management		
(a) Pollution reduction or (c) Biodiversity conservation		
(b) Ecosystem management or (c) Biodiversity conservation		

Resilience to risks

Question: Which is more important…?	Answer: a, b, or c	Give Intensity
(a) Institutional capacity or (b) Infrastructure availability		
(a) Institutional capacity or (c) Natural disaster impacts		
(b) Infrastructure availability or (c) Natural disaster impacts		

Green economic opportunities

Question: Which is more important…?	Answer: a, b, or c	Give Intensity
(a) Green investment or (b) Green innovation		
(a) Green investment or (c) Green employment		
(b) Green innovation or (c) Green employment		

Social Inclusion

Question: Which is more important…?	Answer: a, b, or c	Give Intensity
(a) Access to basic services or (b) Access to capital/resources		
(a) Access to basic services or (c) Gender equality		
(b) Access to capital/resources or (c) Gender equality		

If any, please write reasons for the weights you have given on each dimension on the back page.

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