Climate Change adaptation during the Covid-19 pandemic: some lessons for future climate action

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Abstract. The Covid-19 pandemic is more than a health crisis: it has shaken societies and economies at their core. According to the United Nations, the pandemic can exacerbate poverty and inequalities globally, which makes accomplishing the UN Sustainable Development Goals (SDGs) all the more urgent. This has led to increasing pressure for governments to adjust and implement public policies to address the health crisis and its potential intersections with other local, regional, or global problems. It has become evident that climate risks, which are expected to increase in frequency and intensity due to climate change, are likely to overlap with the Covid-19 pandemic and the public health responses. This poses a crucial policy challenge: while keeping in mind the climate goals and containment of the pandemic, governments are increasingly faced with the urgency of defining options for adaptation to climate and biodiversity changes. Investing in interdisciplinary and cross-sectoral risk assessments is evidently off the essence. Proposed solutions also need to be better integrated, considering interactions, trade-offs, and associated benefits. We believe that integrating ecosystem services—the benefits that people derive from nature—in development strategies will help bring about more sustainable trajectories. Many SDGs rely, indeed, on the provision of one or more ecosystem services. Understanding how these services can bolster multiple objectives is essential to synergistic planning and cost-effective interventions to build targeted resilience to climate change. This paper details potential ecosystem services contributions to the achievement of the SDG's environment-related targets, based on a cross-analysis of a set of documents aimed at fostering Morocco's climate-resilient development. It required to identify entry points and tools to assess in advance the role of ecosystem services in supporting the SDGs in Morocco and finally to introduce a conceptual framework to study these complex relationships in the face of multiple risks and challenges.

Key words: ecosystems, climate change, adaptation, sustainable development, Covid-19

1. Introduction

"This has been an unprecedented year (2020) for people and planet. The Covid-19 pandemic has disrupted lives worldwide. At the same time, the heating of our planet and climate disruption has continued apace. Record heat, ice loss, wildfires, floods and droughts continue to worsen, affecting communities, nations and economies around the world."[1]

These are the words of UN Secretary-General Antonio Guterres in the foreword to the *United in Science* report (LUTERBACHER et al. 2020), a multi-organization high-level compilation of the latest climate science information.

It is tempting to view climate change and the recent Covid-19 pandemic as distinct, discrete predicaments, but their interrelations are complex and dynamic (LIDSKOG et al. 2020). The Covid-19 pandemic, like climate change, appears to disproportionately affect the most disadvantaged communities (IPCC, 2014; DOUGLAS et al. 2020) already struggling with other social crises, such as growing inequalities, economic instability, and forced displacement. For every nation, the pandemic has had a widely negative impact. Still,

[1] *United in Science* report - Overall coordination and editing by WMO - 2020.

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these effects are likely to be felt most strongly in developing and least developed countries, whose capacities and resources to face the economic and social challenges are limited.

With the formal adoption of the UN Sustainable Development Goals (SDGs) in 2015, the interdependence between human well-being and climate change was globally recognized. While the present pandemic is threatening the implementation of the SDGs, which are expected to be achieved by 2030, it is imperative to integrate them into individual and global healthcare decisions (HEGGEN et al. 2020). Indeed, health must be considered in a broader context, paying particular attention to social structures and infrastructures, working and living conditions, and—concerning strategies to tackle climate change—the loss of biodiversity and wild habitats (OTTERSEN & ENGEBRETSEN 2020). In addition, greater attention should be paid to interdependencies, notably across sectors and societal actors (STAFFORD-SMITH et al. 2017) to promote policy coherence and enforce coordination. Indeed, the outcome of solutions that depend on countries' efforts and organizations to deal with the economic, social, and political dimensions cannot be measured with cause-and-effect linearity (STIGLITZ et al. 2006), especially under the pressure of negative externalities brought forth by the pandemic.

Managing ecosystems to protect nature and achieve sustainable sourcing and ensure equitable access to the benefits and services they provide is essential to achieving the human, societal, economic, and cultural well-being ambitions embodied in the SDGs (DE CLERCK et al. 2016). Meeting individual or multiple SDGs targets requires a solid grasp of how the services provided by nature can contribute to the adoption of a transdisciplinary approach to environmental management. Ecosystem services models can offer practical tools to facilitate decision-making at national and local levels by assessing trade-offs and synergies across sectors.

It seems appropriate to undertake adaptive measures to limit negative impacts, explore development opportunities and reduce vulnerability and hazard exposure as an organizational principle that enables us to understand the relationship between the system and its composite parts. All these elements are inextricably linked to each other (IPCC, 2014). Furthermore, as adaptation capabilities encompass various transdisciplinary aspects of the environment, this multi-sectoral approach is a welcomed starting point for a reflection on the systemic, reciprocal ties between environment and society on which this article focuses.

The purpose of this paper is to identify entry points and tools to further analyse the potential contribution of ecosystems services to the SDGs and thereby outline a potential pathway for their integration into national SDGs policy considerations and planning in Morocco. Too often, ecosystem services are undervalued in the planning of policies and actions, leading to potentially ineffective long-term solutions. On the contrary, ecosystem services-based solutions should complement technological, social, and institutional ones to fulfil the ambitious SDGs agenda by identifying the most efficient pathways to sustainable development while avoiding trade-offs with other goals (WOOD et al. 2017). We used information gathered through the analysis of a wide range of high-level documents aimed at supporting and fostering climate-resilient development.

2. Materials and Methods

Morocco, particularly exposed to the risks associated to climate change, stated in its Nationally Determined Contribution (NDC 2015) that the country's national vision should be oriented to mitigate the effects of these risks (*"preserve its territory and civilization most appropriately, effectively responding to the vulnerabilities of its territory and implementing an adaptation policy that builds resilience for all of its population and its economic actors to face these vulnerabilities"*). In line with sustainable development and the 2030 Agenda, it emphasizes that there need not be a trade-off between environmental sustainability and development.

In some way or another, every SDG touches on environmental health and the long-term and

widespread impacts of climate change. However, we traditionally pay particular attention to specific goals when dealing with nature preservation. Moreover, due to the large number of SDG targets, we decided to cull the number of targets to evaluate by excluding policy-oriented targets and those that lack a direct environmental link. It leaves 36 targets across 7 SDGs for consideration (Table 1):

- SDG 6: Clean Water and Sanitation, including ensuring access to safe and affordable drinking water and sanitation, improving water quality and water-use efficiency, and protecting and restoring water-related ecosystems.
- SDG 7: Affordable and Clean Energy, including ensuring access to affordable, reliable and modern energy and increasing the use of renewable energy.
- SDG 11: Sustainable Cities and Communities, which covers access to adequate, safe, affordable and sustainable housing, transportation and public green spaces; inclusive and sustainable urbanization; protecting the world's cultural and natural heritage; reducing deaths and economic losses due to natural disasters; and reducing the adverse per capita environmental impact of cities.
- SDG 12: Responsible Production and Consumption, which is about promoting resource and energy efficiency, sustainable infrastructure, and providing a better quality of life for all.
- SDG 13: Climate Action, an urgent call to reduce greenhouse gas emissions, strengthen resilience to climate change and natural disasters and support the UN Framework Convention on Climate Change.
- SDG 14: Life Below Water, which targets marine pollution, ocean acidification and overfishing, calls for more sustainable management, protection and conservation of marine and coastal ecosystems.
- SDG 15: Life on Land, including protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably managing forests and halting and reversing land degradation and biodiversity loss.

Table 1. Sustainable Development Goals and selected evaluated Targets in which environmental dimensions of sustainable development are fully fleshed out

SDG	Title	Goal	Targets
SDG6	Clean Water & Sanitation	Ensure availability and sustainable management of water and sanitation for all	6.1; 6.2; 6.3; 6.4
SDG7	Affordable & Clean Energy	Ensure access to affordable, reliable, sustainable and modern energy for all	7.1; 7.2; 7.3; 7.b
SDG11	Sustainable Cities & Communities	Make cities and human settlements inclusive, safe, resilient and sustainable	11.1; 11.2; 11.4; 11.5; 11.6; 11.b
SDG12	Responsible Production & Consumption	Ensure sustainable consumption and production patterns	12.1; 12.3; 12.5; 12.8; 12.a; 12.b; 12.c
SDG13	Climate Action	Take urgent action to combat climate change and its impacts	13.1; 13.2; 13.3
SDG14	Life Below Water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	14.1; 14.2; 14.3; 14.4; 14.5; 14.7; 14.a
SDG15	Life on Land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	15.1; 15.2; 15.3; 15.4; 15.5

We evaluated links between the selected SDGs targets (Table 1) and specific ecosystems services from CICES V5.1 (Table 2), Common International Classification of Ecosystem Services (2017). We opted for version 5.1 as this version extends but does not depart from the previous and more common CICES V4.3. We chose the CICES classification due to its hierarchical organization applying the three major sections of services: (i) provisioning, (ii) regulating and (iii) cultural, basically defined in the same way as in the Millennium Ecosystems Assessment (MA) and

TEEB[2] classifications (Haines-Young and Potschin-Young, 2018). Its structure makes it possible to detail the most appropriate level of response and makes it easy to combine results, especially during more generalized comparisons. In addition, to avoid duplication in the assessment of ecosystem services, this classification does not include supporting services, i.e. processes and functions that do not directly benefit society.

According to the "cascade model" (POTSCHIN-YOUNG et al. 2017), this classification focuses specifically on the "final services" of nature, which directly contribute to human well-being through the benefits that they support such as health or security. As we aim to evaluate the importance of good ecosystem services management to contribute to specific SDGs targets in a given national context, we have compared some of the public policy instruments that define the framework for action against global warming and promote sustainable development in Morocco. These documents are: (i) the National Determined Contribution (NDC)[3] that Morocco presented to the United Nations Framework Convention on Climate Change (UNFCCC) on June 5, 2015, and (ii) the Volunteer National Review (VNR)[4] on the implementation of the SDGs submitted by Morocco in 2020.

Through qualitative content analysis, we began by identifying which governance mechanisms could contribute to the implementation of the NDC. We then grouped the material according to which mechanisms can be used to fulfil the NDC's objectives. Each mechanism corresponds to a type of governance instrument, such as legislative measures or citizen behavioral changes. These mechanisms differ in scope and nature but converge in their purpose.

In the present study, as the NDC does not necessarily reflect all national climate policies, we focused on what Morocco, through its NDC, has chosen to emphasize as key elements to address climate change in a sustainable way. For this purpose, it has been necessary to combine the analysis with the VNR focusing on sustainable development data related to governance mechanisms. In addition, both instruments reflect an integrative approach, as the NDC deals with different dimensions of climate challenges. Actually, it provides a basis for further integration in other areas, such as policy design for achieving the SDGs, and most of the sectors considered in the NDC are related to both mitigation and adaptation to climate change (HSU et al. 2020). Adaptation literature emphasizes that many aspects of the development agenda are highly relevant for building resilience to climate change. Indeed, adaptation responses must reduce direct climate risks, such as extended droughts, but also ought to take into account the contextual conditions that make different groups of people particularly vulnerable to climate impacts.

The multiple roles assumed by public authorities raise the question of whether the roles are complementary or contradictory in sectors that can provide effective climate action while promoting other aspects of sustainable development. We have therefore paired each governance mechanism with the ecosystem services that best contribute to national efforts aimed at meeting the challenges of social and economic development and strengthening the resilience of the natural environment to climate change. We identified several combinations where ecosystem services could positively contribute to the attainment of an SDG target. We calculated the co-occurrence of ecosystem service contributions to common targets to detect likely points of cross-service and cross-target interactions. This enabled us to highlight the combinations where one or more ecosystem services could play a significant role in attaining SDGs targets. We then concentrated our efforts on these highly relevant combinations as, based on the analysis, decisions affecting these services are expected to have the most significant potential impact on SDGs outcomes.

[2] The Economics of Ecosystems and Biodiversity – TEEB

[3] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Morocco%20First/Morocco%20First%20NDC-English.pdf

[4] https://sustainabledevelopment.un.org/content/documents/26405VNR_2020_Morocco_Report_French.pdf

Table 2. CICES V5.1 classification

Categories	Typology	Classes
Provisioning	Food	Cultivated terrestrial plants grown for nutritional purposes
		Plants cultivated by in- situ aquaculture grown for nutritional purposes
		Animals reared for nutritional purposes
		Animals reared by in-situ aquaculture for nutritional purposes
		Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition
		Wild animals (terrestrial and aquatic) used for nutritional purposes
	Water	Surface water for drinking
		Surface water used as a material (non-drinking purposes)
		Freshwater surface water used as an energy source
		Coastal and marine water used as energy source
		Ground (and subsurface) water for drinking
		Ground water (and subsurface) used as a material (non-drinking purposes)
		Ground water (and subsurface) used as an energy source
	Non-mineral substances or ecosystem properties used for nutrition, materials or energy	Wind-energy
		Solar-energy
		Geothermal
	Raw materials, medicinal resources	Fibers and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)
		Cultivated plants (including fungi, algae) grown as a source of energy
		Fibers and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials)
		Plants cultivated by in- situ aquaculture grown as an energy source
		Fibers and other materials from reared animals for direct use or processing (excluding genetic materials)
		Animals reared to provide energy (including mechanical)
		Fibers and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials)
		Animals reared by in-situ aquaculture as an energy source
		Fibers and other materials from wild plants for direct use or processing (excluding genetic materials)
		Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy
		Fibers and other materials from wild animals for direct use or processing (excluding genetic materials)
		Wild animals (terrestrial and aquatic) used as a source of energy
	Genetic materials	Seeds, spores and other plant materials collected for maintaining or establishing a population
		Higher and lower plants (whole organisms) used to breed new strains or varieties
		Individual genes extracted from higher and lower plants for the design and construction of new biological entities

		Animal material collected for the purposes of maintaining or establishing a population
		Wild animals (whole organisms) used to breed new strains or varieties
		Individual genes extracted from organisms for the design and construction of new biological entities
Regulating & Maintenance	Waste treatment (water purification), air quality regulation	Bio-remediation by micro-organisms, algae, plants, and animals
		Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals
		Smell reduction
		Noise attenuation
		Visual screening
	Erosion prevention	Control of erosion rates
		Buffering and attenuation of mass movement
	Regulation of water flows, regulation of extreme events	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
		Wind protection
		Fire protection
		Regulation of the chemical condition of freshwaters by living processes
		Regulation of the chemical condition of salt waters by living processes
	Pollination	Pollination (or 'gamete' dispersal in a marine context)
	Biological control	Seed dispersal
		Maintaining nursery populations and habitats (Including gene pool protection)
		Pest control (including invasive species)
		Disease control
	Maintenance of soil fertility	Weathering processes and their effect on soil quality
		Decomposition and fixing processes and their effect on soil quality
	Climate regulation	Regulation of chemical composition of atmosphere and oceans
		Regulation of temperature and humidity, including ventilation and transpiration
Cultural	Recreation and ecotourism	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions
		Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions
	Information and cognitive development	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge
		Characteristics of living systems that enable education and training
	Inspiration for culture, art and design, aesthetic information	Characteristics of living systems that are resonant in terms of culture or heritage
		Characteristics of living systems that enable aesthetic experiences
		Elements of living systems that have symbolic meaning
		Elements of living systems that have sacred or religious meaning
		Elements of living systems used for entertainment or representation

3. Results

While almost all ecosystem services can be paired with one or more targets, the most represented services were related to the provision of food and water. Most of the combinations involved SDG 14 "life below water" and SDG 15 "life on land" suggesting a focus on habitat and biodiversity preservation (Table 3). On the other hand, other ecosystem services, including "non-mineral substances", "raw materials", "genetic materials", "biological control", or "pollination" were less represented. While this does not infer a lesser importance, it signifies a relative priority among ecosystem services in reason of the contribution these services can make towards the SDGs and targets selected.

Some disproportionately represented combinations appeared to carry significant weight. Provision of food and water were the most frequently identified while also contributing to the most considerable number of distinct targets, with 16 and 23 targets respectively, followed by "regulation of extreme events" with 16 targets. This showcases high levels of awareness of the risks for the most vulnerable people, particularly when it comes to the targets related to SDG 6 "clean water and sanitation", SDG 11 "sustainable cities and communities", SDG 14 "life below water" and SDG 15 "life on land". It emphasizes the importance of a national strategy to reduce risks linked to natural hazards, particularly in relation to water stress and water-use efficiency.

Cultural ecosystem services also appeared to play a meaningful role. These are defined as the "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (REID et al. 2005). They are the result of dynamic, complex, physical or spiritual relationships between ecosystems and humans, across landscapes and often over long periods. They result from human-ecosystem interactions and can be associated with every ecosystem, from uninhabited wilderness areas and coastal ecosystems to urban green spaces (HIRONS et al. 2016). According to CICES, cultural ecosystem services can be divided into two categories: (a) those related to physical and intellectual interactions with ecosystems and (b) those that are better defined as spiritual or symbolic (HAINES-YOUNG & POTSCHIN 2013). "Recreation and eco-tourism" and "information and cognitive development", including traditional and local knowledge, received a significant number of target combinations, 13 and 19 targets, respectively.

3.1. Nexus

New integrated approaches and tools are needed to address the challenges posed by multiple and often conflicting human needs and demands and successfully achieve the SDGs (WOOD et al. 2017). Any single approach, even one based on quantifying ecosystem services, cannot solve these overlapping problems. It is therefore primordial to address synergies and trade-offs between sectors. Indeed, there is an opportunity to co-develop actionable knowledge from nexus assessments for problem-solving so as to simultaneously achieve multiple SDGs (LIU et al. 2018). For this reason, we have focused our analysis on exploring potential nexuses to emphasize connections, synergies, and trade-offs.

SDG 12 "responsible production and consumption", SDG 14 "life below water" and SDG 15 "life on land" received the greatest number of distinct ecosystem service contributions with 31, 31 and 54 ecosystem services (Table 3). With this in mind, we can safely assume that inter-sectoral interactions will help avoid negative spill-overs, that is, the transfer of problems from one sector to another without actually solving them. Here, a circular economy, a way to reframe wastes as valuable resources instead of negative production externalities, can help reduce environmental footprints and improve livelihoods. Moreover, this nexus could help reconcile human health efforts, environment and development-oriented targets within and across the SDGs, and national development strategies.

In the case of Morocco, linking marine (SDG 14) and terrestrial processes (SDG 15) could be the source of potential solutions. Still, little is known about the synergies and trade-offs of nexuses or the full potential of marine and coastal systems to help meet resource needs and environmental

sustainability. Despite marine systems making up about 70% of the Earth's surface and their great potential for providing food, energy, and other ecosystem services (e.g. desalination of seawater to mitigate freshwater scarcity), little attention has been paid to marine and coastal systems (LIU et al. 2018).

Table 3. Ecosystem Services and SDGs Targets combinations identified

		Provisioning					**Regulating & Maintenance**							**Cultural**		
		Food	Water	Non-mineral substances	Raw materials, medicinal res.	Genetic materials	Waste treatment	Erosion prevention	Regulation of extreme events	Pollination	Biological control	Maintenance of soil fertility	Climate regulation	Recreation and ecotourism	Information / cognitive dev.	Inspiration for culture
SDG 6	6.1		■													
	6.2		■				■									
	6.3		■				■		■							
	6.4	■	■						■							
SDG 7	7.1		■	■	■								■			
	7.2		■	■	■								■			
	7.3		■	■	■								■			
	7.b			■	■											
SDG 11	11.1	■	■		■		■						■	■		■
	11.2												■			
	11.4													■		■
	11.5		■					■	■		■	■	■		■	■
	11.6	■	■				■		■							
	11.b								■						■	
SDG 12	12.1	■	■			■		■	■	■	■	■			■	■
	12.3	■	■			■	■	■				■			■	
	12.5	■					■		■						■	
	12.8														■	
	12.a														■	
	12.b			■			■	■					■	■		■
	12.c			■			■									
SDG 13	13.1		■					■	■				■		■	
	13.2	■	■	■	■			■					■		■	
	13.3														■	
SDG 14	14.1						■		■				■			
	14.2	■	■			■				■	■			■	■	
	14.3								■					■	■	
	14.4	■	■				■			■				■		
	14.5	■	■				■							■	■	
	14.7	■	■				■		■				■	■		■
	14.a														■	
SDG 15	15.1	■	■		■	■	■	■	■		■	■	■	■	■	■
	15.2	■	■			■		■	■		■	■		■	■	■
	15.3	■	■			■		■	■		■	■		■	■	■
	15.4	■	■		■	■		■	■		■	■		■	■	■
	15.5	■	■		■	■			■		■	■		■	■	■

To expand upon the nexus framework and increase the number of interactions, we decided to draw out potential opportunities for synergies across services combinations (Figure 1). While many of the services were thought to contribute to one or two SDGs as their primary focus, food provision and water provision appeared central to a large number of SDGs (Table 3). These services represent potentially important interaction spaces (15) for trade-offs or synergies across services, and they may be considered in tandem for the concurrent attainment of several sustainable priorities. At the policy level this nexus should be considered at multiple scales. Morocco, for

instance, is a major food producer and exporter, which in turn requires substantial energy and water, leading to growing conflicts over water resources and shortages. Food and water's connections with energy impact health, food, energy and water policies at several levels.

This interlinked approach depends on a wide range of expertise. The need for broader information and cognitive development has been abundantly clear throughout the analysis. Cultural ecosystems services can create interaction spaces able to enhance the relevance of research by incorporating stakeholders' experiences and needs and so fill knowledge gaps. Moreover, recent advances in technology and the proliferation of data are creating new opportunities for monitoring the progress and performance of multi-scale development efforts. Indeed, new and non-traditional data sources will be paramount to the success of such endeavors at a social-political-environmental level (RIZZO et al. 2020).

	Food	Water	Non-mineral	Raw materials	Genetic	Waste	Erosion	Extreme events	Pollination	Biological	Soil fertility	Climate	Recreation	Information	Inspiration
Food		15	1	5	8	8	7	10	3	7	7	4	10	11	8
Water	15		4	8	8	9	9	12	3	8	8	9	10	12	9
Non-mineral	1	4		5	0	2	2	0	0	0	0	5	1	1	1
Raw materials	5	8	5		3	2	3	3	0	3	3	6	4	4	4
Genetic materials	8	8	0	3		2	6	6	2	7	7	1	6	8	6
Waste treatment	8	9	2	2	2		3	6	1	1	2	5	6	4	4
Erosion prevention	7	9	2	3	6	3		7	1	6	7	5	5	9	7
Extreme events	10	12	0	3	6	6	7		1	7	7	5	7	12	8
Pollination	3	3	0	0	2	1	1	1		2	1	0	2	2	1
Biological control	7	8	0	3	7	1	6	7	2		7	2	6	8	7
Soil fertility	7	8	0	3	7	2	7	7	1	7		2	6	8	7
Climate	4	9	5	6	1	5	5	5	0	2	2		8	8	9
Recreation	10	10	1	4	6	6	5	7	2	6	6	8		8	9
Information	11	12	1	4	8	4	9	12	2	8	8	8	8		7
Inspiration	8	9	1	4	6	4	7	8	1	7	7	9	9	7	

Figure 1-Map of the pairwise combinations of ecosystem services co-occurring across combinations

4. Conclusion

Climate change and the Covid-19 pandemic demonstrate that we are now living in an era where the growth of human activities has caused a significant impact on the global environment (ASAYAMA et al. 2020). At the same time, the two crises have brought widespread inequality to light. Since disparities in society are intrinsically linked to changes in ecological condition (Hamann et al, 2018), measures that mitigate risks can also help to reduce existing inequalities because both climate change and the pandemic impact mainly the most vulnerable in society. Thus, the emphasis on the social, political, and economic health and well-being of human systems and their interaction with Earth's natural systems appears fundamental. As health and equality are closely linked, protecting human and environmental health serves the central pledge of SDGs: "leave no one behind".

The results of the analysis which make up the pith and core of this paper reflect the critical role of ecosystem services in supporting the SDGs in relation to national and local policy strategies. While we did not assess the contribution of all services to all SDG targets, we identified some ecosystem services that appear to play an important part in achieving targets across seven environment-related goals. These are expected to contribute to a wide array of targets consistent with climate and development policy plans. The intertwined approaches highlight the need and potential benefits of taking a broad, multi-sector,

multi-scale and multi-actor perspective in the face of the challenges and risks of the modern world.

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References

ASAYAMA S., EMORI S., SUGIYAMA M., KASUGA F. & WATANABE C. (2020): Are we ignoring a black elephant in the Anthropocene? Climate change and global pandemic as the crisis in health and equality - Sustainability Science. DOI: 10.1007/s11625-020-00879-7

DOUGLAS M., KATIKIREDDI S-V., TAULBUT M., MCKEE M. & MCCARTNEY G (2020): Mitigating the wider health effects of covid-19 pandemic response. DOI: 10.1136/bmj.m1557

DECLERCK F-A., JONES S., ATTWOOD S;, BOSSIO D., GIRVETZ E., et al. (2016): Agricultural ecosystems and their services: the vanguard of sustainability? Curr. Opin. Environm. Sustain., **23**, 92-99

HAINES-YOUNG R. & POTSCHIN M. (2013): CICES V4. 3-Revised report prepared following consultation on CICES Version 4, August-December 2012.EEA Framew. Contract No. EEA/IEA/09/003, Cent. Environ. Manag., Univ. Nottingham, UK

HAINES-YOUNG R. & POTSCHIN-YOUNG M. (2018): Revision of the Common International Classification for Ecosystem Services (CICES V5.1): A Policy Brief. One Ecosystem. 3. e27108. 10.3897/oneeco.3.e27108

HAMANN M., BERRY K., CHAIGNEAU T. et al (2018): Inequality and the biosphere. Annu. Rev. Environ Resour. **43**, 61–83. DOI: 10.1146/annurev-envir on-10201 7-02594 9

HEGGEN K, SANDSETA T-J & ENGEBRETSEN E (2020): Covid -19 and sustainable development goals. DOI: 10.2471/BLT.20.263533

HIRONS M., COMBERTI C. & DUNFORD R. (2016): Valuing Cultural Ecosystem Services. Annual Review of Environment and Resources. 41. 10.1146/annurev-environ-110615-085831.

HSU A., BRANDT J., WIDERBERG O., CHAN S. & WEINFURTER A. (2020): Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs), Climate Policy, 20:4, 443-457, DOI: 10.1080/14693062.2019.1624252

IPCC (2014): Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects: Working Group II Contribution to the IPCC Fifth Assessment Report: Volume 1: Global and Sectoral Aspects vol 1. Cambridge University Press, Cambridge.

LIDSKOG R., ELANDER I. & STANDRING A. (2020): Covid -19, the Climate, and Transformative Change: Comparing the Social Anatomies of Crises and Their Regulatory Responses. Sustainability, **12**, 6337. DOI: 10.3390/su12166337

LIU J., HULL V., GODFRAY H-C-J., TILMAN D., GLEICK P., HOFF H., PAHL-WOSTL C., XU Z., GON CHUNG M., SUN J. & LI S. (2018): Nexus approaches to global sustainable development - Nature Sustainability September 2018, pp. 466–476

LUTERBACHER J., PATERSON L., SOLAZZO K. & CASTONGUAY S. (Editor) (2020): United in Science report - Overall coordination and editing by WMO.

OTTERSEN O-P. & ENGEBRETSEN E. (2020): Covid-19 puts the Sustainable Development Goals center stage. Nat Med 26, 1672–1673. DOI: 10.1038/s41591-020-1094-y

POTSCHIN-YOUNG M., HAINES-YOUNG R., GÖRG C., HEINK U., JAX K. & SCHLEYER C. (2017): Understanding the role of conceptual frameworks: Reading the ecosystem service cascade. Ecosystem Services. **29**. DOI: 10.1016/j.ecoser.2017.05.015.

REID W-V., MOONEY H-A., CROPPER A., CAPISTRANO D., CARPENTER S-R., et al. (2005): Ecosystems and Human Well-Being. Washington, DC: Island Press

RIZZO A., SIFEDDINE A., FERRAZ B., HUBER-SANNWALD E., COPPOCK D-L., ABRAHAM E-M. & BOUCHAOU L. (2020): The Agadir Platform: A Transatlantic Cooperation to Achieve Sustainable Drylands. In: Lucatello S., Huber-Sannwald E., Espejel I., Martínez-Tagüeña N. (eds) Stewardship of Future Drylands and Climate Change in the Global South. Springer Climate. Springer, Cham

STAFFORD-SMITH D-M., GRIGGS D, GAFFNEY O., ULLAH F., REYERS B., KANIE N., STIGSON B., SHRIVASTAVA P., LEACH M. & O'CONNELL D. (2017): Integration: the key to implementing the sustainable development goals. Sustain Sci **12**, 911–919

STIGLITZ J., OCAMPO J-A., SPIEGEL S., FRENCH-DAVIS R. & NAYYAR D. (2006): Stability with growth: macroeconomics, liberalization and development. Oxford University Press, Oxford. DOI: 10.1093/0199288143.001.0001

WOOD S-L-R., JONES S-K., JOHNSON J-A., BRAUMAN K-A., et al. (2017): Distilling the role of ecosystem services in the Sustainable Development Goals. 2017 Elsevier B.V.

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