# A Sustainable COVID-19 Response, Recovery, and Redesign: Principles and Applications of the Triple R Framework

-IGES Discussion Paper-

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## 1. Introduction

In less than a year, COVID-19 has morphed from a worrying disease confined to wild animals to a devastating pandemic affecting much of humanity. The speed and scale of its spread have caused immense suffering and loss. A death figure currently standing at more than 1.6 million people is the most unsettling indication of this toll (Johns Hopkins University Coronavirus Resource Center 2020). Meanwhile, the economic lockdowns and slowdowns accompanying COVID-19 have reversed steady declines in global poverty for the first time in three decades and precipitated the "deepest recession since World War II" (United Nations 2020; World Bank 2020). Fortunately, governments have not sat idly as these impacts mounted. COVID-19 has motivated policymakers in nearly every corner of the world to adopt responses to the immediate impacts of the virus. It has also persuaded policymakers to invest between 12 and 15 trillion dollars globally in recovery packages that could help countries pivot onto more sustainable development paths (OECD 2020).

A critical question is whether policy and investment decisions made in the wake of COVID-19 are inclusive, resilient and sustainable enough to bring about a course change in development (Rasul 2020). COVID-19, like many crises, has opened an opportunity to break down the multiple barriers and interests preventing departures from business-as-usual development. Growing evidence of COVID-19's interrelationship with a variety of environmental concerns—from pollution prevention to biodiversity preservation—could inform the cross-sectoral strategies needed to capitalise on this opportunity (Zhou and Moinuddin 2021). However, this window of opportunity could close soon if policymakers are ill equipped to marshal that evidence to formulate an integrated package of COVID-19 decisions. Such a failure could lead policymakers to focus narrowly on COVID-19's most pressing health and economic impacts while allocating funding to piecemeal collections of short-sighted investments and self-serving interests.

The purpose of this paper is to outline the design features of framework that helps policymakers steer a more inclusive, resilient and sustainable course. What the Institute for Global Environmental Strategies (IGES) calls the "Triple R" Framework consists of connecting targeted "response" interventions with broader "recovery" policies and related stimulus spending while "redesigning" socioeconomic systems to

support the framework's response and recovery elements. In recommending that policymakers use this framework, the paper emphasises that government decisions should aim to adhere to several principles: 1) coherence in content; 2) consistency over time; 3) scalability across space; and 4) alignment of supportive stakeholder interests. Meeting these criteria in policy areas such solid waste, air pollution, and water/wastewater management as well as sustainable lifestyles and ecosystem preservation will strengthen the integration within and across COVID-19 decisions. It will further expand stakeholder support and financial resources committed to a more inclusive, resilient, and sustainable world that can avert future planetary crises (Rockström et al. 2009).

The remainder of this discussion paper is organised as follows. The next section defines the core elements of the Triple R Framework. The third section applies that framework to environmental issues where IGES has active research portfolios. The final section concludes by underlining how concepts such as vertical and horizontal integration, the regional circulating and ecological sphere (Regional-CES) as well as social cohesion can provide the "glue" holding together different sectoral applications of the Triple R Framework.

## 2. COVID-19 and The Triple R Framework

COVID-19 is a zoonotic disease—an infectious disease that spreads from animals to human beings. Like many other zoonotic diseases, the reason for its transmission to humans is a combination of contact between people and animals, and the compatibility of the virus with humans as hosts. Zoonoses are not new. The black plague resulted in up to 200 deaths across Eurasia and North Africa hundreds of years ago and is still present today (DeLeo and Hinnebusch 2005). Although zoonoses collectively kills far fewer people than non-communicable diseases like cancer and heart disease, they contribute substantially to global disease tolls. Malaria remains the biggest killer in Africa, where it takes the lives of hundreds of thousands every year (IHME 2020).

Prior to the industrial and transportation revolution, localised lifestyles made global pandemics virtually impossible: transmission was confined to small communities with limited contact with the rest of the world. Now, however, people travel from forests to towns to cities in days if not hours. COVID-19, more than any other pandemic in recent history, has highlighted the potential for transmissible disruptions to spread rapidly due to phenomenal mobility. Given the potential for dangerous disruption, policymakers from the local to the global levels need to know how to respond to, and recover from, COVID-19 as well as how to redesign physical infrastructures, policymaking institutions, and socioeconomic systems to avoid future crises. Avoiding these crises also requires capitalising on the opportunity for disruptive change.

## 3. Barriers and Shocks

The main reason disruption is important is that a collection of technical, social, financial, and institutional constraints can come together to preserve *status quo* resource-intensive modes of development. Frequently with the support of special interests benefiting from that *status quo*, these reinforcing barriers

lock in unsustainable development patterns and close off alternative development paths (Sandén and Azar 2015; Frantzeskaki and Loorbach 2007; Safarzyńska and van den Bergh 2010). Yet, there are opportunities for breaking unsustainable inertias and impasses.

Shocks are among the factors that can help in this regard. Shocks refer to unexpected, one-off occurrences that can serve as "focusing events" to clear barriers and weaken interests preventing reforms (Cowan and Hultén 1996; March and Olsen 1989; Hughes, Strachan, and Gross 2013; Kinzig et al. 2006; Emam, Grebel, and Tudor 2020). They can also "provide a window of opportunity for small-scale initiatives and efforts across different levels of society" to support systemic changes (Novalia and Malekpour 2020). Such jolts can take the form of natural disasters (the 2011 Fukushima triple disaster), financial crises (the 2007 Lehman banking crisis), landmark events (the 2008 Beijing Olympics), and, most relevant to this paper, pandemics.

Shocks may be important but insufficient to bring about transformative change. Another contributing factor are policy decisions made in the wake of shocks. The lack of bold and decisive policy action following shocks can reduce stakeholder enthusiasm and limit resources for significant changes. Without a framework that can help integrate decisions and align interests, such a bold and decisive change is unlikely. The next step, then, is outlining the defining features of a framework that can help integrate decisions and align interests related to COVID-19 behind more sustainable change (OECD 2018).

### *3.1 Illustrating the Triple R Framework*

The main building blocks of the Triple R Framework are as follows.

- Response refers to targeted interventions to address emergencies, and improve the well-being of those suffering from the problem in question. Measures to deal with rapidly increasing medical waste are an important response.
- Recovery refers to broader policy and spending decisions aimed at stimulating a depressed economy and employment in ways that can alter development paths. From a sustainability perspective, not just any recovery but a green recovery is essential.
- Redesign refers to restructuring of infrastructures, institutions and systems to make post-COVID economy and society more sustainable over the long term. Increasing resilience to pandemics like COVID-19 is a critical goal of the redesign.

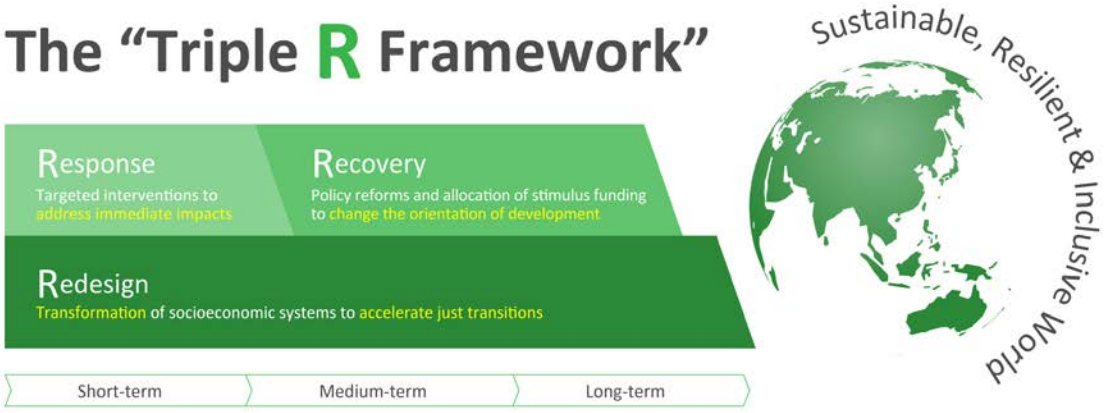



Figure 1: The Triple R Framework

As suggested in Figure 1, these Rs are not be pursued in isolation. Rather, policymakers are advised to think how the initial response interacts with the broader recovery; and how redesigns of infrastructure, institutions and others systems interact with the response and recoveries. Further, as suggested in Table 2, each of the Rs is different in its outlook over time, scale of desired changes, and targeted stakeholders. This variation will arguably facilitate formulating decisions in ways that adhere to a few previously mentioned sustainability principles: 1) coherence in content; 2) consistency over time; 3) scalability across space; and 4) alignment of supportive stakeholder interests.

Table 2: Differentiating the Response, Recovery, and Redesign

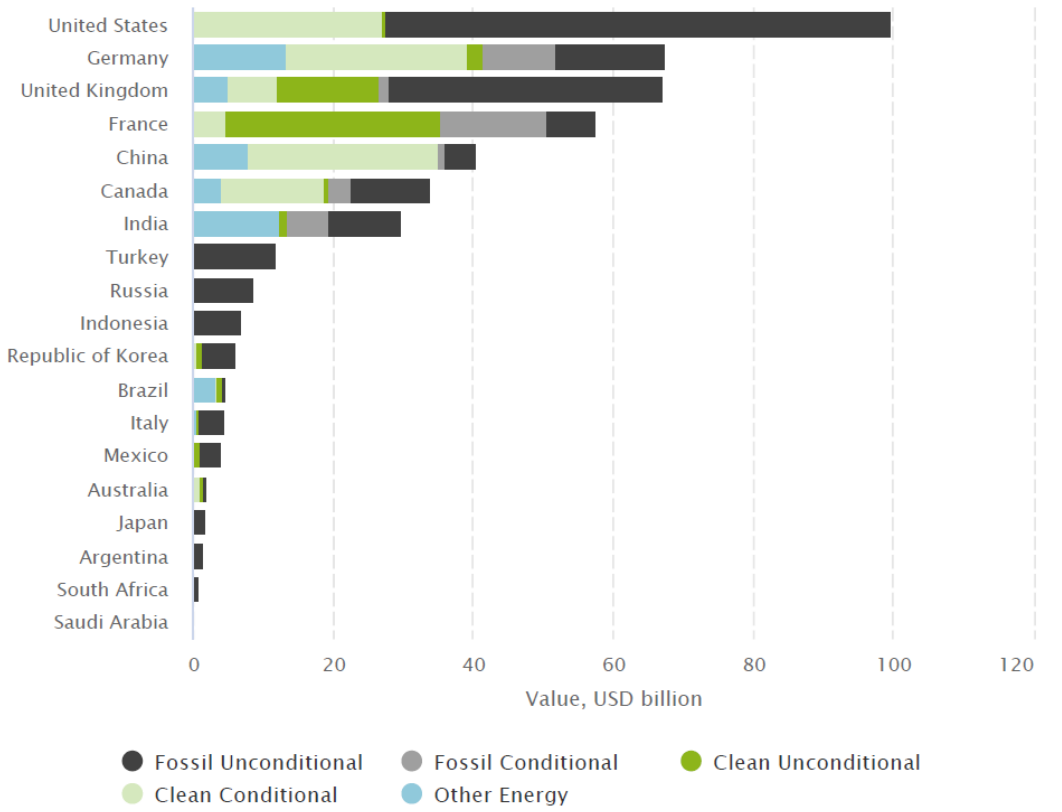
| Dimensions / The "Rs" | Outlook | Scale of Change | Targeted Stakeholders |
|---|---|---|---|
| *Response* | Near-term | Narrow intervention | Immediately affected groups |
| *Recovery* | Medium- to long-term | Broader policy change and stimulus allocation | Supportive government agencies and other sympathetic groups |
| *Redesign* | Near- to long-term | Physical infrastructure, policymaking institutions, and socioeconomic systems | Coalitions of existing and newly empowered interests |

### *3.2 Substantive Coherence, Spatial Scalability, Temporal Consistency, and Stakeholder Alignment*

There are no shortage principles and criteria advocated in the work on sustainability. One of the unique features of the Triple R Framework is it aims to support consideration of these principles.

The first criteria involves achieving coherence in the substance of policies (OECD 2018). For some, this entails eliminating contradictions in policy provisions (Gauttier 2004). As illustrated and described in Box 1, some countries are working at cross-purposes on climate and energy with fossil fuel energy accounting for more than half of the stimulus (IISD et al. 2020). For others, it involves aiming for creating synergies—and avoiding trade-offs—between policies. To carry forward the same example, fossil fuel subsidies can have carryover effects on infrastructure and lifestyle choices that undermine efforts to promote renewables and energy conservation.

Box 1: Incoherence in Stimulus Packages




The Energy Policy Tracker, a collaborative research initiative led by IISD with six core members and 15 contributing partners, provides the latest information about COVID-19 government policy responses from a climate and energy perspective. The tracker originally covered the G20 countries, but the coverage has been gradually widened to 28 countries. The analysis provides a detailed overview of the

public finance flows as determined by recovery packages. These flows are categorised as fossil fuel supporting or clean energy supporting measures with or without conditions. Overall, 216 billion USD or 54% of trackable pledged public funds are committed to fossil fuels with 146 billion USD or 36% flowing to clean energy and another 10% allocated for other energies (e.g. nuclear) in G20 countries, while Germany, France and China allocated majority of recovery related financial resources for clean energy.

Source: IISD et al. 2020

Consistency over time is a second desirable property. Having a consistent outlook is useful because, to cite an example, governments may address immediate environmental impacts of medical waste but continue to support unsustainable production and consumption systems. Policymakers will hence need to about relationships between short and long-term changes (Markard, Raven, and Truffer 2012). At the same time, long-term thinking should not be delay urgent interventions or lasting systemic changes (Jänicke 2009).

A related consideration involves ensuring scalability across space. The most straightforward application of this principle involves avoiding harmful spillovers from transboundary environmental issues: for instance, policies should not incentivise companies upstream to discharge effluent downstream. Yet, drawing from the work on multi-level transitions and ecology, scale in this paper also refers to ensuring a good fit between narrower response interventions, wider recovery policies, and even more extensive redesigns to bring about the spread of innovations (Markard, Raven, and Truffer 2012; Folke et al. 2007).

A final criteria involves aligning key stakeholder interests. This property is critical because, without agreements between government agencies, businesses, and other stakeholders, progressively larger changes will be difficult (Amanuma et al. 2018). This alignment often does not happen naturally; it is frequently attributable to institutions that shape whether agencies and actors have the opportunities and incentives to work together (Jones 2002). As such, the redesign element and efforts to construct multi-sector coordination for COVID-19 will be important (Rasul 2020).

## 4. Applying the Triple R Framework

This section demonstrates how the Triple R Framework can be applied to several environmental concerns. As demonstrated in Table 2 and Box 2, COVID-19 interacts with many environmental other development issues. The section applies the framework to waste, air quality, water/wastewater management, sustainable lifestyles and ecosystem preservation.

Two caveats are in order before presenting these applications. First, the applications illustrate how different sets of actions *could* fit into the R categories. Different stakeholders may use the framework differently; describing an option fitting each R may not be possible or desirable in some contexts. To some degree, the paper overstretches an issue to demonstrate the framework's use. Second, the framework is applied to different sets of sectoral concerns. Doing so runs counter to the paper's support for sectoral integration. The paper's final section underline on how enablers can help integrate sectoral concerns.

Table 2: COVID-19's Environmental Impacts

| Policy Area | Impacts |
|---|---|
| Waste Management | • Increased disposable equipment waste and single-use plastics<br>• Chemical disinfectants affected local biota<br>• Reduced commercial and industrial waste<br>• Increased residential waste |
| Air Pollution | • Reduced some forms of air pollution and $CO_2$<br>• Increases in ground level ozone and exposure to indoor air pollution in some locations<br>• Exposure to air pollution may worsen impacts of COVID |
| Water/Waste Water Management | • Reduced water pollution<br>• COVID-19 contamination in wastewater become an early warning system |
| Sustainable Lifestyles | • Expanded opportunities for lifestyles and work changes<br>• Reduced travel and outside dining reduce waste and energy use<br>• Increased residential waste and energy use |
| Biodiversity | • Land cover change plays a big role in the spillover of zoonotic disease from wild animals to humans or domestic animals suggest that<br>• The more fragmented natural areas, the more people are likely to encounter vectors of zoonotic disease<br>• Capture and trade of vector organisms carries especially high risk, particularly bats, rodents, and primates |

Box 2: Human-Environment Interactions in the Era of COVID-19

As the world suffers one of the most significant threats to human security since World War II, COVID-19 has sharpened decision-makers' awareness of human interactions with the environment. A new book entitled *Environmental Resilience and Transformation in Times of COVID-19* demonstrates that the key to a resilient future lies is meaningfully factoring these human-environment interactions into the following environmental policy areas.

Water resources: planning, management and governance

The book underlines that COVID-19 offers a valuable perspective on the implications of water resources and wastewater management on human health and well-being. These implications include the importance of strengthening water management resource analysis and monitoring to help remove the virus in contaminated media and halt its spread in densely populated areas. They also include understanding how lockdowns have affected wastewater and water quality in environmentally rich areas such as coastal ecosystems.

Air quality: Monitoring, fate, transport, and drivers of socio-environmental change

COVID-19—and particularly the stoppage of socioeconomic activities during the lockdown—illustrates how human activities interact with the atmospheric environment. The book demonstrates how lockdowns led to significant but potentially temporary improvements in air quality and health, chiefly from reduced industrial and transport emissions. At the same time, the section demonstrates new ways to track the potential spread of airborne viruses.

Marine and lacustrine environments

COVID-19 has also had wide-ranging impacts on marine, lagoonal and lacustrine environments. These environments are critical to the survival of corals and dependent biota while serving as a vital link in the food chain. The book shows that some of these environments, such as lakes and lagoons, have seen post-lockdown improvements in water quality and increases in the fish population. The book further underlines that marine ecosystems and policies to protect the ecological health of these coastal habitats are more critical than ever in the COVID-19 era.

The Sustainable Development Goals and environmental justice

The book's final section makes the links between COVID-19 and sectoral integration under the Sustainable Development Goals (SDGs) as well as social inclusion as part of the push environmental justice. The book illustrates that COVID-19 opens an opportunity to accelerate progress on the SDGs, especially if policymakers become better equipped to factor interlinkages into their decisions. The book further notes the need to bring in women, communities depending on forests or living in mountain regions, and other marginalised stakeholders into COVID-19 management decisions.

Source: Ramanathan et al. 2021

### *4.1 Applications to Waste Management*

#### *Response*

The pandemic has underscored that inadequate and inappropriate handling of masks, personal protective equipment and other medical waste can have serious health and environmental consequences. For example, since many COVID patients isolate at home but do not get hospitalised, household waste from contaminated individuals could spread COVID-19 (Penteado and Castro 2020). Some governments have already adopted initiatives to respond to the waste management challenge; yet, there is scope for improving on these efforts (UNEP, IETC, and CCET 2020).

Especially for developing countries with limited infrastructure, the starting point for improving on the response is a rapid assessment of existing waste, especially health care waste. This assessment can help governments understand the COVID-19-related changes in the waste levels, types, and flows; the current collection, segregation, transfer, storage and treatment methods and available resources and technologies; as well as challenges and gaps in waste management due to COVID-19. Based on this rapid assessment,

governments can draft a pandemic contingency plan to address the identified challenges and gaps identified. The plan should also include safety measures for waste workers and strengthen welfare mechanisms to protect lives and livelihoods in the event of virus infection, transmission, and outbreak. Given the potential risks, in many cases the government should prioritise the management of COVID waste over other waste streams.

### *Recovery*

Follow-through actions should draw upon and feed into recovery efforts. In this case, local governments should tap stimulus resources to strengthen waste management policies and sustain service provision. This may also entail policies aimed increase the circularity of products and value chains though reducing, reusing, and recycling. The recovery plan should also include measures to meet waste minimisation and recycling targets while promoting source separation, take-back or deposit return systems and community collection or introduction of material recovery facilities. This set of recovery actions could accompany efforts to eliminate manual contact with waste, fortify supply chains, and improve working conditions for formal and informal sectors (as the informal sector plays a key role in waste management in developing countries). Where resource limitations reduce funding, peer learning from other countries on safe and affordable treatment and disposal methods for medical and health care waste could help compensate.[1] This learning could also capacities to record impacts on health, safety, amounts of waste generation, collection, recycling and disposal--information that can help redesign waste management systems in the third R.

### *Redesign*

The contingency and recovery plans could set a foundation for redesigns of consumption and production systems. For national and local governments with waste management policies/strategies and action plans, the redesign could aim to translate existing plans into infrastructure supporting holistic waste management and cradle-to-grave lifecycle product management. It will also be critical to strengthen relevant government agencies and bridge silos between policymakers focusing on waste, consumption, and public health. Comparable changes will be needed in engaging with relevant businesses as well as within businesses themselves (for instance, businesses improved reusability, reparability and recyclability while ensuring safe use so more resources). Finally, redesign elements should aim to open opportunities for marginalised groups in waste planning process—for instance, ensuring that women and those belonging to the informal economy can participate in decisions regarding waste specifically and consumption and production generally.

## *4.2 Applications to Air Pollution*

### *Response*

The primary motivation for government responses to COVID-19 is protecting health since the virus poses an immediate health threat. Protecting health, however, also entails safeguarding populations from

[1] See, for example, UNEP Sustainability Assessment of Technologies (SAT) guidance on Best Available Technologies and Best Environmental Practices (BAT/BEP).

additional environmental stresses that could exacerbate COVID-19's impacts. This includes exposure to different types of air pollution. Part of the COVID policy response, therefore, should focus on reducing exposure to harmful pollutants. For some pollutants and locations, reductions in motorised transport as well as energy and industrial emissions have occasioned lockdowns. However, not all forms of pollution have fallen as exemplified by increases in tropospheric ozone and indoor air pollution. Interventions targeting increasing ozone and indoor pollution should be part of the government response—for instance, with requirements to reduce emissions of ozone precursors from solvents and agricultural sources. In rural areas, subsidies for cleaner cooking fuels can help safeguard against exposure to indoor air pollution.

Even areas that have seen pollution levels drop during the slowing of economic activity may experience rebounds as economies restart. Efforts to minimise rebounds by promoting public transport with adequate safety considerations (regular disinfecting of seats and surfaces, social distancing, temperature checks) as well as non-motorised transport could also be part of the response, complementing other transport elements (See Box 3 for a description of possible changes related to sustainable transport). Some of the effort to avoid rebounds should begin should also feature in recovery packages and systems redesigns that follow.

### Box 3: The Triple R Framework and Sustainable Transport

COVID-19 and accompanying lockdowns have had significant impacts on the transport sector. The pandemic may have also opened opportunities to advance sustainable transport.

Responses could encourage behavioural changes supported by digitalisation. For example, digital transactions for payment on public transport, especially in developing countries, could avoid physical contact and prevent the spread of the virus. Smart technology, internet of things (IOT) and big data may help to improve the operation and management of public transport in matching demand and supply to avoid overcrowding, minimise loss for operators, and generate other environmental benefits. It may also support integration among modes between the main haul of public transport and first-last miles by other means of transport and the informal transit system. E-commerce can also help to avoid unnecessary trips by public transport, while teleworking and distance learning for higher education may help to avoid overcrowded public transport for commuting and school trips.

As for recovery and redesign, reforming urban infrastructures is necessary to create urban mobility resilience. Nudge tools for sustainable transport behaviour could include improvements in the physical environment, provision of better public transport, and complementary changes to biking and walking infrastructure. Those change could be feasible through attractive new walking environments, involving, for instance, biophilic design, walkable urban design and behaviour change programs. Incentives to enhance the mobility of low-income households such as free public transport could support these reforms. Smart technologies to nudge users to change their mobility behaviours on a personal level could also be helpful.

### *Recovery*

The recovery elements should aim to achieve a few goals when it comes to air pollution. The most critical is limiting rebounds in emissions during after the reopening of economies. For urban pollution, some of the investment could flow to non-motorised and forms of public transport. Yet a complementary set of efforts to boost support for electric vehicles—since there is likely to be a strong demand for personalised transport even with improvements in non-motorised and public transport. Similarly, rebounds in emissions could be limited by using stimulus funding to invest in clean energy and energy efficient industries. It may be particularly important in this regard to offer support for small and medium enterprises (SMEs) because they are more likely to lack the means to withstand pandemic reductions in resources.

### *Redesign*

The redesign element could also target areas related to the recovery and response. These include infrastructure investments in, for instance, bike lanes and wider sidewalks as well as instituting new zoning rules and parking restrictions on personalised transport in areas with heavy traffic. In a similarly motivated effort, governments could aim to redesign energy systems to accommodate a larger proportion of renewables in the energy mix. These systemic changes could accompany institutional reforms to agencies and divisions in charge of air pollution regulation. These include requiring rigorous analyses of air pollution and health impacts in a range of policy decisions as well as enhanced coordination across agencies responsible for air pollution, health and climate change.

## *4.3 Applications to Water/Waste Water Management*

### *Response*

Water and wastewater treatment systems are not only critical to public health, but also environmental sustainability. Several interventions related to water and wastewater therefore merit attention in the COVID-19 response. These begin with ensuring access to sufficient levels of clean water for both hygienic and health purposes since hand washing prevents the spread of COVID-19 (World Health Organization 2020). They also entail narrowing disparities in water access that could reduce hand washing and multiple the risks of transmission of COVID-19 for disadvantaged populations (Brauer et al. 2020). In countries where water *access* is not an issue, part of the response will involve managing rising demands residential water use (in the United States reporting a more than 20% increase) (Mendoza 2020) and a decrease in industrial water use with accompanying impacts on water revenue (International Water Association 2020). Finally, some parts of response could focus on strengthening testing regimes by monitoring RNA strands in wastewater to identify levels and peaks in COVID-19 (Takeda et al. 2021, 2020). All of the above responses would benefit from assessments of the impacts of COVID-19 on water resources, and various modern technologies such as remote sensing and GIS can help in this regard (Avtar et al. 2020).

### *Recovery*

The recovery elements follow the likely consequences of the response, especially reductions in revenue for water service providers. This may include allocating stimulus finance to prevent services from going bankrupt due to loss of revenue from COVID-19. Public-private partnerships, in particular, could reduce financial risks now and in the future. The stimulus may also be allocated to address reductions in industrial water revenue for service providers as increases in domestic water revenue have not fully compensated for reductions. Policies from national and local governments to protect water and wastewater service providers would be helpful in this regard. National and local governments (with backstopping support from international agencies) would also be well advised to provide special assistance to low-income households finding it difficult to pay for water. Frameworks to support innovation and new workstyles in the water and wastewater sector to build a robust and sustainable system need to be supported by sustainable financing.

### *Redesign*

Water and wastewater treatment systems are vitally important infrastructure, protecting health as well as boost other forms of resilience. Taking into account weaknesses revealed during the pandemic, governments and other actors related to the water and wastewater sectors can work together to strengthen these systems. Some suggested system changes include transferring of services online (such as bill collection). Others should aim to smooth disruption of value chains caused by social distancing that has also affected operation and maintenance such as procurement of chemicals or mechanical/electrical parts.

An arguably broader set of system-level actions should aim for balancing volumes needed for health, food production, and energy production. These systemic changes will cut across multiple development dimensions and may reveal trade-offs in the process. For example, the automation of treatment processes can help reduce the needed number of workers onsite and ensure business continuity—though it may lead to increased energy use. By the same token, renewable energy solutions can help decrease the carbon footprint and strengthen resilience to disruptions (e.g. gas, diesel) and electricity grid failure—though it might cost jobs. Institutional arrangements that can help maximise synergies and minimise tradeoffs will be increasingly important for the above instances.

## 4.4 Applications to Sustainable Lifestyles

### *Response*

When it comes to sustainable lifestyles, the response could begin by targeting the mental stress from many of the measures governments introduced, such as lockdowns, banning of in-person meetings and travel, and school closures. It could also aim to ease the challenges of working from and eating at home, taking advantage of distance education, and participating in online gatherings. Bearing these impacts in mind, the response should focus on measures to provide support to health care workers, women, racial and ethnic groups, and social segments who have demonstrably been most adversely affected by sudden lifestyle changes, and those who could not avail themselves of safer alternatives (ILO 2020; UN Women 2020; Hardy and Logan 2020; Urban Wire 2020).

### *Recovery*

For recovery, governments should also aim to maximise sustainability gains (reductions in energy consumption and food waste) and mitigate less sustainable impacts (sharp increases in residential energy consumption and plastic use) (Medical Xpress 2020) from the behavioural changes. Some of the other practical examples for mitigating the negative impacts and maximising positive effects have already been illustrated in sections on waste management, air pollution, and wastewater treatment.

On a deeper level, reflecting on the meaning of recovery is also needed. Recovery does not simply imply returning to an unsustainable *status quo*. This is partially because socioeconomic rules, infrastructures and urban services (discussed more in the redesign subsection) will not be rolled back easily. It also suggests that recovery necessitates reconsidering envisioning what a sustainable lifestyle entails, not only individually but also at community, city and higher levels of the collective. Without reconceiving what it means to sustainably recover on individual and collective levels, some of the positive behavioural changes resulting from energy-saving and GHG reductions will be overwhelmed by unsustainable reversions in urban, work, education and other systems.

### *Redesign*

Some of the redesign should aim for building resilient living contexts for those whose livelihoods have suffered. Additionally, it is important to note that while people adopt new behaviours and learn to live differently, socioeconomic institutions and technologies also change. Societies need to ensure that the design and application of new rules and technologies go through an inclusive and transparent process and account for different voices. Otherwise, while the post-pandemic society will allow specific categories of people to enjoy more sustainable and resilient living, other groups will be left more vulnerable. In other words, fair participation and inclusiveness should be necessary criteria in the redesign of sustainable living after the pandemic. Doing so would be in line with the just transition concept and shed light on the root causes of unsustainability (See Box 4 for elaboration on this point).

#### Box 4: The Just Transition and COVID-19

The origins of just transition trace to growing concerns over the socioeconomic consequences of energy extraction and decarbonising energy sources (Behles 2013; Newell and Mulvaney 2013; Heffron and McCauley 2017; Cha 2018). In this context, it was intended to motivate governments to intervene to create jobs in green sectors and provide a safety net and compensation for workers and communities adversely affected by changes in energy markets (Healy and Barry 2017).

However, the concept may also have wider applications to other environmental stresses and accompanying transitions. This is because often environmental issues expose different vulnerabilities of workers, locals, communities and regions across locations and sociodemographic groups. An expanded interpretation of just transition could therefore be used to encourage entire communities, locales and society more broadly to become environmentally sustainable and socially just. The COVID-19 pandemic has arguably paid insufficient attention to these justice issues. Just transition hereafter can help support the redesign of existing socioeconomic and political structures to not only further achieve inter- and

intra-generational equity, sustainability and cultural diversity, but also offer a deeper understanding of the root causes of unsustainability.

## *4.5 Applications to Biodiversity*

### *Response*

Conservationists and the conservation-minded have been trying for decades to slow or halt the destruction and degradation of natural areas in various parts of the world. COVID-19 provides an additional reason to do so. Responding to the pandemic by slowing or halting the destruction and/or degradation of natural areas will reduce the amount of contact between people and potential vectors of zoonoses (Keesing et al. 2010). In cases where the destruction of natural areas leads to their fragmentation, relatively frequent contact between people and wildlife will continue. Rather than destroying the remaining fragments of habitat and the various potential benefits it offers, a more appropriate management response would be to manage and monitor them, and to limit access to them where appropriate.

### *Recovery*

The varying forms of legislation regulating the capture and trade of wild species in different parts of the world would benefit from an overhaul (Borzée et al. 2020). This does not suggest bans, but rather improvement and standardisation based on best practices, and improved enforcement. Many people's livelihoods are reliant on the trade so a ban could potentially have a devastating effect on some, while in other cases it could drive the trade underground, where best practices are even less likely to be followed (Roe et al. 2020). Threatened species, however, should be afforded the protection needed to save them from extinction.

Among the regulations that appear in need of improvement or better enforcement is the treatment of wild-caught animals. Besides the ethical implications of poor treatment (e.g., live confinement in small enclosures that are exposed to onlookers from all sides), studies suggest that animals subjected to high levels of stress are more susceptible to disease (Plowright et al. 2015; Owen et al. 2012) and consequently transmission to humans. Furthermore, keeping different species near one another increases the likelihood that they will acquire their neighbours' pathogens prior to being purchased.

A final element of the recovery would be to improve our limited understanding of which kinds of environments, and interactions with them, are most likely to increase the risk of spillover. Around the world research needs to be encouraged and supported for this purpose, and to enable us to better understand how differing contexts affect these complex relationships. Such research—along with the above improving the design and enforcement of regulations—could be part of recovery packages.

### *Redesign*

The complete elimination of pathogens is impossible, thus some risk of another pandemic occurring is unavoidable. We can minimise this risk, however, through some modest redesign of social systems. Some solutions are conceptually simple but difficult to implement: ending the trade of high-risk species like bats and rodents, for example. There exist serious efforts to monitor pathogens potentially capable of causing the next pandemic (Epstein and Anthony 2017; Morse et al. 2012). To detect spillover before transmission spreads too widely to control, monitoring high-risk communities, such as those with frequent contact with wildlife, may be feasible (Wolfe and Dunavan, C. P. Diamond 2007).

## 5. Conclusions and Way Forward

This paper has outlined the main design features of the Triple R Framework and demonstrated that it is potentially consistent with several desirable principles. The paper then demonstrated the application of that framework to waste, air pollution and water/wastewater management, as well as sustainable lifestyles and ecosystem preservation. The below table summarises the possible applications broken by each R. It also contrasts these with a less sustainable business-as-usual interpretation of the framework.

Table 3: Applications of the Triple R Framework

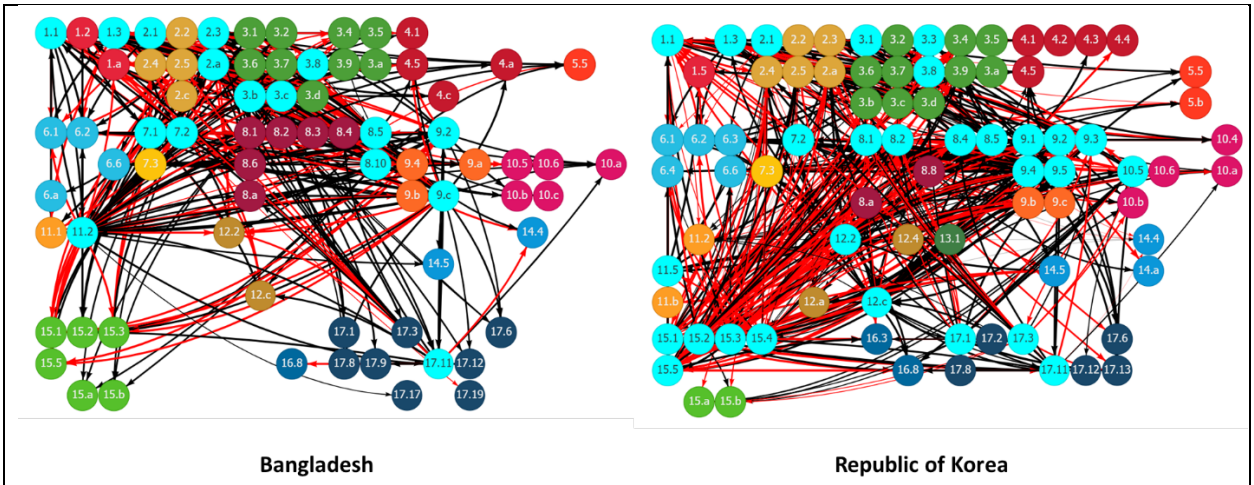
| Issue | Response | Recovery | Redesign |
|---|---|---|---|
| **Sustainable** | | | |
| Waste | • Share procedures to dispose of dangerous waste | • Include waste management in industry support<br>• Retain reductions in industrial waste; reduce household waste | • Promote circular economy and sustainable consumption and production systems<br>• Promote inclusive decision making<br>• |
| Air Quality (including Climate) | • Target polluted communities, ozone pollution, and indoor air pollution with remedial measures | • Industry support focus on sustainable transport, not unsustainable industries<br>• Retain reductions in air pollution and energy savings | • Accelerate energy transition to renewables and electric vehicles<br>Promote inclusive decision making |
| Water/waste water | • Ensure water access for hand washing<br>• Monitor waste water for COVID | • Include water/wastewater in industry support<br>• Retain reductions in industrial wastewater/water; reduce household waste | • Integrated water management and inclusive decision making |
| Lifestyles | • Target disadvantaged people and communities for remedial measures | • Offer opportunities to deliberate over meanings of recovery<br>• Retain reductions in industrial wastewater/water; reduce household waste | • Promote new forms of collaborative learning and decision making |
| Biodiversity | • Manage and monitor and (where necessary) limit access to habitats | • Target resources at improved and standardization and enhanced enforcement for the capture and trade of wild species | • Strengthen monitoring of pathogens and high-risk communities |
| **BAU** | | | |
| | • Lockdowns<br>• Social distancing<br>• Testing, masks | • Income support for fossil fuels and pollution deregulation | • Make operations resilient to future pandemics with end of pipe" changes to infrastructure and systems |

While the above points summarise the paper, a few additional arguments merit highlighting in the conclusion. The first involves the integration across the environmental concerns discussed in the application of the Triple R Framework. For the purposes of illustration, the paper outlined the application to specific issues, noting in some instances the importance of working across sectors—for instance, the discussion of water refers to possible synergies and trade-offs. As governments employ the framework, greater emphasis needs to be placed on working across different waste, air, water, livelihoods as well as issues such as climate change. Building coherence across issues will be critical to ensuring that COVID-19 strategies are indeed sustainable and strong, and keep windows of opportunity open. There are tools that can help identify interlinkages across issues covered under the Sustainable Development Goals (SDGs) that will also facilitate integration.

### Box 5: Using Interlinkages to Evaluate COVID-19 Recoveries

A recent study by Zhou and Moinuddin (2020) employed an interlinkages analysis to assess the impact of COVID-19 and potential areas for aligning recovery efforts with the SDGs. The analysis focused on existing and planned recovery measures for Bangladesh and the Republic of Korea. To analyse interlinkages, specific policy measures were mapped against SDG targets (Zhou et al. 2019).The identified synergies and trade-offs were then reviewed in terms of 1) their current relationship with different SDGs; and 2) the long-term implications for resilience and sustainability.

The results at the analysis varied between Bangladesh and Korea (see figure below). In Bangladesh, responses to the pandemic sought to address livelihood concerns of vulnerable people and avoid interruptions to small and medium enterprises (SMEs). As such, a continued focus on poverty reduction, improving agricultural productivity and transportation efficiency could enhance synergies in Bangladesh. However, existing measures did not consider economic and environmental trade-offs such as industrial pollution and ecosystem degradation. On the other hand, the Republic of Korea adopted a more comprehensive set of recovery measures to COVID-19: interventions sought to strengthen social protection, support full and productive employment, guide industrial development, promoting renewable energy, address climate change and restoring ecosystems.




The Impact of COVID-19 measures on achieving SDGs in Bangladesh and the Republic of Korea

Source: Zhou and Moinuddin 2017

Another point pertains to the integration between levels of decision-making. The paper implied some actions will fall to local governments, while others are more likely the responsibility of national governments. If the Triple R Framework is going to generate action on the ground, integration between different levels of decision-making will be critical. The allocation of responsibilities will vary across contexts, but approaches such as the Circulating and Ecological Sphere (CES) that draws upon principles of geography and circular economy could help enable implementation of the framework (Takeuchi et al. 2019).

A related point involves social cohesion. Social cohesion involves the process of "developing wellbeing, sense of belonging, and voluntary social participation" and can work at multiple, interdependent levels of the individual, community, and institutions (Fonseca, Lukosch, and Brazier 2019). In fostering cohesion, there are generally increases in "cooperation for the common good, social and institutional trust, and 'inclusive identity'" (which emphasises peaceful co-existence of different groups and solidarity across groups in society) (Leininger et al. n.d.). This, in turn, can support more inclusive governance and decision-making to addressing systemic vulnerabilities, sharing a common future vision, and ultimately creating sustainable and more equitable systems and institutions. It is also relevant to the "response" and "recovery" components, as the level of cohesion in a society will influence the degree to which the policymaking process and policy implementation are "just".

A final point involves changes in knowledge systems. The paper has focused mostly on changes to infrastructure and institutions in the discussion of redesigning socioeconomic systems. Yet the pandemic suggests there is an arguably more fundamental shift in the paradigms and perspectives that humanity uses to define the goals for such socioeconomic systems. The current crisis may offer an opportunity to revisit the analytical lens through which we view crises, prompting governments and other stakeholders to move outside our comfort zones and reconsider how sustainable societies are defined. Put differently,

redesigning of the systems is about the answer, while redesigning of paradigms and perspectives is more about the questions societies have in the first place.

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## Work Cited

Amanuma, Nobue, Eric Zusman, So-Young Lee, Jagath Dickella Premakumara, Gamaralalage, Bijon Kumer Mitra, Ngoc-Bao Pham, Ryoko Nakano, et al. 2018. **Governance for Integrated Solutions to Sustainable Development and Climate Change: From Linking Issues to Aligning Interests**. Edited by Eric Zusman and Nobue Amanuma. Hayama: IGES. https://www.iges.or.jp/en/about/staff/zusman-eric?page=%2C2.

Avtar, R., P. Kumar, H. Supe, D. Jie, N. Sahu, B.K. Mishra, and A.P. Yunus. 2020. "Did the COVID-19 Lockdown Induced Hydrological Residence Time Intensified the Primary Productivity in Lakes?: Observational Results Based on Satellite Remote Sensing." **Water** 12 (9): 2573.

Behles, D. 2013. "From Dirty to Green: Increasing Energy Efficiency and Renewable Energy in Environmental Justice Communities." **Villanova Law Review**, no. 58: 25–27. https://digitalcommons.law.villanova.edu/vlr/vol58/iss1/3/.

Borzée, A., J. McNeely, K. Magellan, J. R. B. Miller, L. Porter, T. Dutta, K. P. Kadinjappalli, et al. 2020. "COVID-19 Highlights the Need for More Effective Wildlife Trade Legislation. Trends in Ecology and Evolution." **Rends in Ecology & Evolution** 35 (12).

Brauer, M., J. T. Zhao, F. B. Bennitt, and J. D. Stanaway. 2020. "Global Access to Handwashing: Implications for COVID-19 Control in Low-Income Countries." **Environmental Health Perspectives** 128 (5): 057005. https://doi.org/10.1289/EHP7200.

Cha, J. M. 2018. "From the Dirty Past to the Clean Future." In **Routledge Handbook of Climate Justice** edited by T Jafry, 211. Routledge.

Cowan, R., and S Hultén. 1996. "Escaping Lock-in: The Case of the Electric Vehicle." **Technological Forecasting and Social Change** 53 (1): 61–79.

DeLeo, F. R., and B. J. Hinnebusch. 2005. "A Plague upon the Phagocytes." **Nature Medicine** 11 (9): 927–28. https://doi.org/10.1038/nm0905-927.

Emam, S., T. Grebel, and A-D. Tudor. 2020. "Do We Need Disasters to Adopt More Environmental Policies?" **Sustainability and Society**

Epstein, J. H., and S. J. Anthony. 2017. "Viral Discovery as a Tool for Pandemic Preparedness." **OIE Revue Scientifique et Technique** 36 (2): 499–512. https://doi.org/10.20506/rst.36.2.2669.

Folke, C., L. Pritchard Jr, F. Berkes, J. Colding, and U. Svedin. 2007. "The Problem of Fit between Ecosystems and Institutions: Ten Years Later." **Ecology and Society** 12 (1).

Fonseca, X., S. Lukosch, and F. Brazier. 2019. "Social Cohesion Revisited: A New Definition and How to Characterize It." **Innovation: The European Journal of Social Science Research** 32 (2).

Frantzeskaki, N., and D. Loorbach. 2007. "Towards Governing Infrasystem Transitions. Reinforcing Lock-in or Facilitating Change?" **Technological Forecasting and Social Change** 77 (8): 1292–1301.

https://doi.org/10.1016/j.techfore.2010.05.004.

Gauttier, P. 2004. “Horizontal Coherence and the External Competences of the European Union.” *European Law Journal* 10: 23–41.

Hardy, B.L., and T.D. Logan. 2020. “Racial Economic Inequality Amid the COVID-19 Crisis.” *The Hamilton Project, Essay*, 2020. https://www.brookings.edu/wp-content/uploads/2020/08/EA_HardyLogan_LO_8.12.pdf.

Healy, N., and J. Barry. 2017. “Politicizing Energy Justice and Energy System Transitions: Fossil Fuel Divestment and a ‘Just Transition.’” *Energy Policy* 108: 451–59.

Heffron, R. J., and D. McCauley. 2017. “What Is the ‘Just Transition’? Geoforum.” *GeoForum* 88: 74–77.

Hughes, N., N. Strachan, and R. Gross. 2013. “The Structure of Uncertainty in Future Low Carbon Pathways.” *Energy Policy*, 45–54.

IISD, IGES, OCI, ODI, Stockholm, SEI, and Columbia University SIPA Center on Global Energy Policy. 2020. “Energy Policy Tracker.” 2020. https://www.energypolicytracker.org/.

ILO. 2020. *ILO Monitor: COVID-19 and the World of Work*. Sixth.

Institute for Health Metrics and Evaluation (IHME). 2020. “Global Health Data Exchange.” 2020. http://ghdx.healthdata.org/gbd-results-tool.

International Water Association. 2020. “COVID-19: A Utility Leaders’ Response.” https://iwa-network.org/learn/a-utility-leaders-response-to-covid-19/.

Jänicke, M. 2009. “On Ecological and Political Modernization.” In *The Ecological Modernisation Reader. Environmental Reform in Theory and Practice.*, edited by A.P.J. Mol, D.A. Sonnenfeld, and G. Spaargaren, 28–41. Milton Park: Routledge.

Johns Hopkins University Coronavirus Resource Center. 2020. “COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.” 2020. https://coronavirus.jhu.edu/map.html.

Jones, T. 2002. “Policy Coherence, Global Environmental Governance, and Poverty Reduction.” *International Environmental Agreemements: Politics Law Economy* 2: 389–401.

Keesing, F., L. K. Belden, P. Daszak, A. Dobson, C. D. Harvell, R. D. Holt, P. Hudson, et al. 2010. “Impacts of Biodiversity on the Emergence and Transmission of Infectious Diseases.” *Nature* 468 (7324): 647–652. https://doi.org/10.1038/nature09575.

Kinzig, A. P., P. Ryan, M. Etienne, H. Allison, T. Elmqvist, and B. H. Walker. 2006. “Resilience and Regime Shifts: Assessing Cascading Effects.” *Ecology and Society* 11 (1). https://doi.org/10.5751/ES-01678-110120.

Leininger, J., A. Von Schiller, C. Sommer, F. Burchi, C. Fiedler, K. Mross, D. Nowack, and C. Strupat. n.d. “DIE’s Concept of Social Cohesion.” 2020. https://www.socialcohesion.info/concepts/concept/julia-leininger-/-armin-von-schiller-/-christoph-sommer-/-francesco-burchi-/-charlotte-fiedler-/-karina-mross-/-daniel-nowack-/-christoph-strupat.

March, J., and J. Olsen. 1989. “Rediscovering Institutions: The Organizational Basis of Politics.” In , edited by Simon and Schuster.

Markard, J., R. Raven, and B. Truffer. 2012. “Sustainability Transitions: An Emerging Field of Research and Its Prospects.” *Research Policy* 41: 955–67.

Medical Xpress. 2020. “Coronavirus Reminds Us How Livable Neighborhoods Matter for Our Well-Being.” 2020. https://medicalxpress.com/news/2020-04-coronavirus-livable-neighborhoods-well-being.html.

Mendoza, N. F. 2020. “US Home Water Use up 21% Daily during COVID-19 Crisis.” Tech Republic. 2020. https://www.techrepublic.com/article/us-home-water-use-up-21-daily-during-covid-19-crisis/.

Morse, S. S., M. Mazet, J. A. K. Woolhouse, C. R. Parrish, D. Carroll, W. I. Karesh, W. B. Zambrana-Torrelio, C. Lipkin, and pp. 1956–1965). Elsevier. https://doi.org/10.1016/S0140-6736(12)61684-5 Daszak, P. Prediction and prevention of the next pandemic zoonosis. In The Lancet (Vol. 380, Issue 9857. 2012. “Prediction and Prevention of the next Pandemic Zoonosis.” *The Lancet* 380 (9857): 1956–1965.

Newell, P., and D. Mulvaney. 2013. “The Political Economy of the ‘Just Transition.’” *Geographical Journal* 179 (2). https://doi.org/10.1111/geoj.12008.

Novalia, W., and S. Malekpour. 2020. “Theorising the Role of Crisis for Transformative Adaptation.” *Environmental Science & Policy*.

OECD. 2018. “Policy Coherence for Sustainable Development 2018. Towards Sustainable and Resilient Societies.” Paris. https://www.oecd-ilibrary.org/development/policy-coherence-for-sustainable-development-2018_9789264301061-en.

OECD. 2020. “OECD Policy Responses to Coronavirus (COVID-19) Making the Green Recovery Work for Jobs, Income and Growth.” Paris. https://www.oecd.org/coronavirus/policy-responses/making-the-green-recovery-work-for-jobs-income-and-growth-a505f3e7/.

Owen, J. C., A. Nakamura, C. A. Coon, and L. B. Martin. 2012. “The Effect of Exogenous Corticosterone on West Nile Virus Infection in Northern Cardinals (Cardinalis Cardinalis).” *Veterinary Research* 43 (1). https://doi.org/10.1186/1297-9716-43-34.

Penteado, C. S. G., and M. A. S. de. Castro. 2020. “Covid-19 Effects on Municipal Solid Waste Management: What Can Effectively Be Done in the Brazilian Scenario?” *Resources, Conservation and Recycling* 164: 105152.

Plowright, R. K., P. Eby, P. J. Hudson, I. L. Smith, D. Westcott, D. Bryden, W. L. Middleton, P. A. Reid, et al. 2015. “Ecological Dynamics of Emerging Bat Virus Spillover.” *Proceedings of the Royal Society B: Biological Sciences* 282 (1798). https://doi.org/10.1098/rspb.2014.2124.

Ramanathan, A.L., M.P. Sabarathinam, C. Jonathan, P. Kumar, F.M. Arriola, and M.V. Prasanna. 2021. *Environmental Resilience and Transformation in Times of Covid-19*. Amsterdam: Elsevier.

Rasul, G. 2020. “A Framework for Improving Policy Priorities in Managing COVID-19 Challenges in Developing Countries.” *Frontiers in Public Health* 8.

Rockström, J., W. Steffen, K. Noone, A. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, et al. 2009. “Planetary Boundaries: Exploring the Safe Operating Space for Humanity.” *Ecology and Society* 14 (2).

Roe, D., A. Dickman, R. Kock, E. J. Milner-Gulland, E. Rihoy, and M. ’t Sas-Rolfes. 2020. “Beyond Banning Wildlife Trade: COVID-19, Conservation and Development.” *World Development* 163 (January).

Safarzyńska, K., and J. C. J. M. van den Bergh. 2010. "Demand-Supply Coevolution with Multiple Increasing Returns: Policy Analysis for Unlocking and System Transitions." *Technological Forecasting and Social Change* 77 (2): 297–317.

Sandén, B. A., and C. Azar. 2015. "Near-Term Technology Policies for Long-Term Climate Targets - Economy Wide versus Technology Specific Approaches." *Energy Policy* 33 (12): 1557–76.

Takeda, T., M. Kitajima, N.T.T. Huong, A Setiyawan, T. Setiadi, D.T. Hung, and E. Haramoto. 2020. "Institutionalising Wastewater Surveillance Systems to Minimise the Impact of COVID-19: Cases of Indonesia, Japan and Viet Nam." *Water Science and Technology*. https://doi.org/10.2166/wst.2020.558.

Takeda, T., Kitajima M, Abeynayaka A, Huong N.T.T, Dinh N.Q., Sirikanchana K., and Haramoto E Navia M, Sam AA, Tsudaka M, Setiadi T, Hung DT. 2021. "Governance of Wastewater Surveillance Systems to Minimize the Impact of COVID-19 and Future Epidemics: Cases across Asia-Pacific." In *Environmental Resilience and Transformation in Times of Climate Change*. Amsterdam: Elsevier.

Takeuchi, Kazuhiko, Junichi Fujino, Fernando Ortiz-Moya, Bijon Kumer Mitra, Atsushi Watabe, Tomoko Takeda, Zhen Jin, Sudarmanto Budi Nughroho, Hirotaka Koike, and Yatsuka Kataoka. 2019. "Circulating and Ecological Economy - Regional and Local CES: An IGES Proposal." Hayama. https://www.iges.or.jp/en/pub/circulating-and-ecological-economy-regional/en.

UN Women. 2020. "From Insights to Action: Gender Equality in the Wake of COVID-19."

United Nations. 2020. "The Sustainable Development Goals Report." New York. https://unstats.un.org/sdgs/report/2020/.

United Nations Environment Programme (UNEP), International Environmental Technology Centre (IETC), & IGES Center Collaborating with UNEP on Environmental Technologies (CCET). 2020. "Waste Management during the COVID-19 Pandemic: From Response to Recovery." Bangkok. https://wedocs.unep.org/bitstream/handle/20.500.11822/33416/WMC-19.pdf?sequence=1&isAllowed=y.

Urban Wire. 2020. "The COVID-19 Crisis Continues to Have Uneven Economic Impact by Race and Ethnicity." 2020.

Wolfe, N. D., and J. Dunavan, C. P. Diamond. 2007. "Origins of Major Human Infectious Diseases Title." *Nature* 447 (7142): 279–283. https://doi.org/10.1038/nature05775.

World Bank. 2020. "Global Economic Prospects 2020." Global Economic Prospects 2020. 2020. https://www.worldbank.org/en/publication/global-economic-prospects.

World Health Organization. 2020. "Water, Sanitation, Hygiene, and Waste Management for SARS-CoV-2, the Virus That Causes COVID-19: Interim Guidance." Geneva.

Zhou, X., and M. Moinuddin. 2021. "Impacts and Implications of the COVID-19 Crisis and Its Recovery for Achieving Sustainable Development Goals in Asia: A Review from an SDG Interlinkage Perspective." In *Environmental Resilience and Transformation in Times of COVID-19*, edited by A.L. Ramanathan, C. Sabarathinam, M.P. Jonathan, P. Kumar, F.M. Arriola, and M.V. Prasanna. Amsterdam: Elsevier.

Zhou, X., and M. Moinuddin. 2017. "Sustainable Development Goals Interlinkages and Network Analysis: A Practical Tool for SDG Integration and Policy Coherence." Hayama. https://sdginterlinkages.iges.jp/files/IGES_Research Report_SDG Interlinkages_Printing Version.pdf.