Environmental Science and Policy 128 (2022) 41–44

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Six steps to integrate climate mitigation with adaptation for social justice

William J. Ripple [a], William R. Moomaw [b,c], Christopher Wolf [a,*], Matthew G. Betts [a], Beverly E. Law [a], Jillian Gregg [d], Thomas M. Newsome [e]

[a] Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331, USA
[b] The Center for International Environment and Resource Policy, Fletcher School and Global Development and Environment Institute, Tufts University, Medford, MA
[c] Woodwell Climate Research Center, Falmouth, 02540, MA USA
[d] Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331, USA
[e] School of Life and Environmental Sciences, The University of Sydney, Sydney, NSW 2006, Australia

ARTICLE INFO

Keywords:
Climate change
Climate action
Social justice
Climate policy

ABSTRACT

Climate change impacts are accelerating and there is an urgent need to address this global issue. Tackling climate change in an effective and socially just manner needs to involve mitigation strategies that address the underlying causes of climate change, but also adaptation strategies that help us prepare for current and future impacts. Historically, mitigation and adaptation strategies have been treated separately, but there is now growing awareness of important synergies between them. We highlight these synergies across six key areas where humans need to make transformative changes in order to reduce the impacts of climate change, including energy, pollutants, nature, food, population and the economy. In doing so, we show the enormous potential for civil society, government, world leaders and the private sector to take advantage of the fact that mitigation strategies can also provide adaptation opportunities to lessen humanity's suffering as we navigate the uncertainties of the climate crisis.

1. Main text

The climate emergency has arrived, and feedback loops are accelerating change far more rapidly than most scientists anticipated. The adverse consequences now threaten both the biosphere and humanity, and thousands of scientists have warned of “untold human suffering” (Ripple et al., 2020, 2021). In Paris, in 2015, all governments agreed to limit temperature increases to no more than 1.5–2 °C above preindustrial levels. With an increase of just 1.25 °C, the world is already experiencing more frequent and intense major disruptions from extreme weather events, and conditions will become worse with further temperature increases. Climate injustice has resulted where the countries with the greatest emissions are not those with the greatest vulnerability (Fig. 1). To avoid the most severe outcomes, there is an urgent need to ramp up mitigation efforts. Anticipating the consequences of a severely altered climate, it is essential that every country simultaneously implements effective adaptation policies to tackle this global problem. Climate adaptation refers to actions that will help us prepare for the current and future impacts of climate change including adjustments to ecological, social or economic systems. Although climate adaptation and mitigation have historically been treated separately, there is growing awareness of important synergies between them (Swart and Raes, 2007).

Using the six transformative steps of Ripple et al. (2020), here, we propose a science-based call for action suggesting how each step benefits both climate mitigation and adaptation (Fig. 2). These examples are not exhaustive, but demonstrate effective actions we can take for progress on both fronts simultaneously to optimize benefits to humanity. There is considerable overlap and synergy among the steps, so progress will be greatest when the steps are implemented together.

1) *Energy*. While the energy sector is normally associated with mitigation alone, there are numerous opportunities for realizing adaptation and mitigation together. For example, a distributed system of local and regional solar powered buildings has a low carbon footprint (mitigation) but is also more resilient to intense storms and temperature surges than traditional power generation and an aboveground grid that distributes electricity over long distances (adaptation). Similarly, in addition to storing carbon, urban green spaces and trees lower local temperatures, thereby reducing energy needed

* Corresponding author.
E-mail address: wolfch@oregonstate.edu (C. Wolf).

https://doi.org/10.1016/j.envsci.2021.11.007
Received 27 August 2021; Accepted 7 November 2021

for cooling (mitigation) but also improving livability for humans and wildlife (adaptation) (Kabisch et al., 2016).

2) *Short-lived air pollution*. Short-lived emissions such as methane and black carbon (soot) are large contributors to raising temperatures in the near-term. Therefore, reductions in these factors are among the most effective approaches for mitigating climate change to help forestall disastrous climate tipping points. Reducing methane also reduces the formation of tropospheric ozone that contributes to global warming and damages the health of humans and plants including crops. Black carbon is a leading cause of human mortality from air pollution and, after it settles back on Earth, quickens the melting of snow and glaciers upon which millions of people depend for freshwater resources. Reducing black carbon emissions will improve the health of millions and save lives, especially in low income regions that rely on biomass combustion. Thus, reducing methane and black carbon pollution are adaptations that lead to healthier humans, and greater food and freshwater availability that is better adapted to withstand the stresses of climate change (e.g., heat waves and droughts) (Swart and Raes, 2007).

3) *Nature*. Maintaining natural ecosystems has high climate mitigation potential through carbon accumulation and storage but is also the first line of defense against intensified climate-related impacts of droughts, fires, heat waves, floods, hurricanes and other extreme events. Forests and wetlands provide resilience to increased heat waves through regional evaporative cooling, and reduce flooding by limiting runoff and soil erosion. We need to practice proforestation management, which entails allowing existing forests to continue growing to reach their ecological potential (Moomaw et al., 2019). We must also establish strategic forest carbon reserves in mature and old forests where potential carbon density is medium to high under future climate conditions (Buotte et al., 2019; Law and Moomaw, 2021), as these forests store disproportionately greater amounts of carbon and tend to have high genetic and critical habitat value (Betts et al., 2017; Mori et al., 2021). These forests support adaptation through resistance to severe fires and floods and buffer microclimate from temperature extremes for habitat suitability for thermally sensitive fauna (Frey et al., 2016). Finally, conserving and restoring tropical mangroves is particularly important because they provide storm surge protection (adaptation) and simultaneously remove atmospheric carbon dioxide (mitigation) while also providing the additional co-benefit of increasing fish habitat and populations (Global Commission on Adaptation, 2019). Forests offer an array of other benefits to humans, including air and water purification, recreational opportunities, and erosion protection (Phillips et al., 2015; Song et al., 2016; Vincent et al., 2016; Riccioli et al., 2019). Forests are especially important to many Indigenous societies, and Indigenous lands are often among the best protected (Artelle et al., 2019).

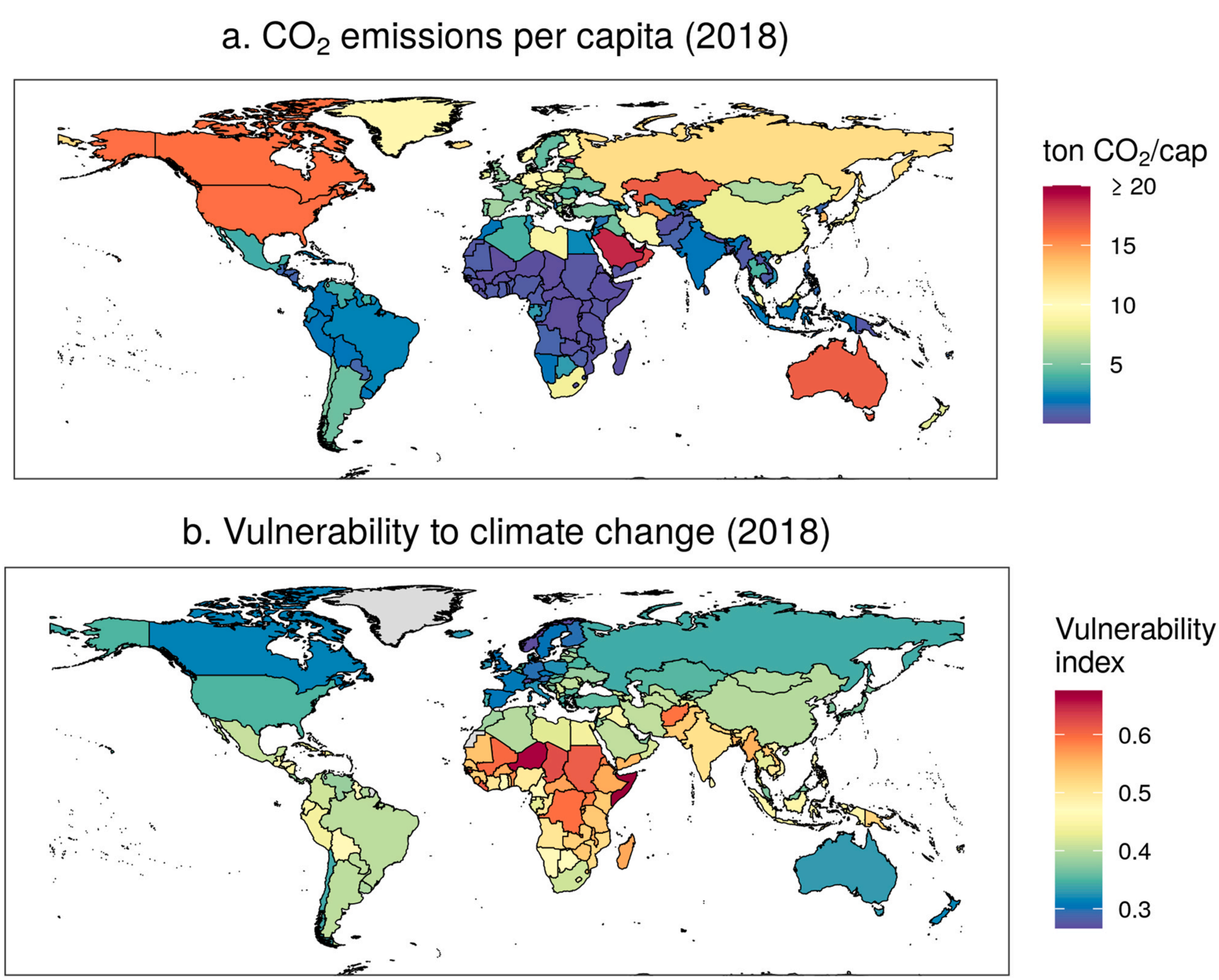

Fig. 1. CO_2 emissions per capita (A) and human vulnerability to climate change (B) in 2018. Vulnerability data are from the Notre Dame-Global Adaptation Country Index (Chen et al., 2015), which incorporates information related to exposure and sensitivity to climate change. CO_2 emissions per capita are from the EDGARv5.0_FT2018 dataset (Crippa et al., 2019), and cover only fossil fuel use and industrial processes and product use.

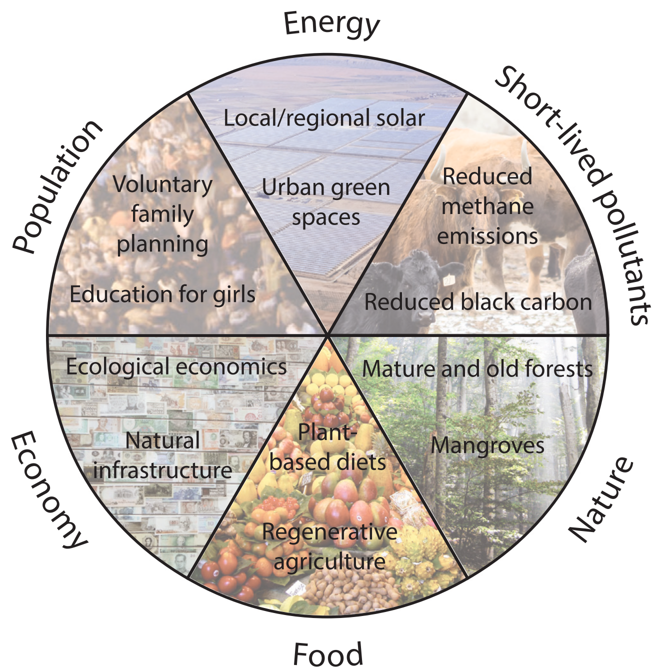

Fig. 2. Examples of synergies between climate mitigation and climate adaptation grouped according to the six transformative steps of Ripple et al. (2020). Each example involves both climate mitigation and adaptation – see the numbered list in the main text for details and additional examples. Image credits (clockwise from Energy): kallerna (CC BY-SA 4.0), Washington State Department of Agriculture (CC BY-NC 2.0), Snežana Trifunović (CC BY-SA 3.0), Daderot (CC BY-SA 3.0), Leon petrosyan (CC BY-SA 4.0), Futurebird (CC BY 2.5).

4) *Food.* Altered diets and agricultural practices are important adaptations with large mitigation potential. Reducing grazing areas and the consumption of animal products by the world's affluent and eating more plant-based foods is a key step for mitigating and adapting to climate change (Ripple et al., 2020). In addition to reducing greenhouse gas emissions and decreasing deforestation, plant-based diets can improve human health, thus increasing resiliency to climatic-related pressures. Promoting plant-rich diets, alternative proteins (meat analogs) and reducing food waste should be priorities. It is also essential to reduce conversion of forestlands to agriculture by producing nutritious food more efficiently on current agricultural land, or even reducing the agricultural footprint. In particular, transitioning to agroforestry, regenerative agriculture, no tillage, perennial polyculture, shifting rice cultivation to drylands to reduce methane emissions, and other conservation measures can contribute to both climate mitigation and adaptation by enhancing soil carbon and water storage while increasing food security. This in turn can increase yields and water retention, making crops more resilient to a changed climate (Rosenzweig and Tubiello, 2007).
5) *Economy.* As the context for each of the above solutions, there is an urgent need to revise economic activities, remove inequities, and shift away from endless economic growth at any cost toward long-term sustainability and justice as described by ecological economics (Daly and Farley, 2011). This could be done by transitioning to a circular economy, wherein goods that reach the end of their life can serve as resources for others (Stahel, 2016). Curbing investments in unsustainable industries like fossil fuels and forest bioenergy and investing instead in zero-carbon alternatives, natural solutions and utilizing natural infrastructure rather than hard infrastructure (engineering solutions that rely on concrete and steel or massive earth moving) would help to adapt to and also mitigate climate change (Seddon et al., 2020). As an alternative to defending and supporting declining and climate destructive industries, economic adaptation requires investment in climate supportive alternatives. The financial and investment industry has great leverage for bringing about change. Governments need to adapt by taxing carbon, abolishing taxing preferences for climate damaging industries, incentivizing climate friendly industries, and ideally, by requiring that climate mitigation initiatives include adaptation components.
6) *Population.* Policies that provide quality education to all are essential to ensuring that society can effectively adapt to a rapidly changing climate. A more educated and knowledgeable population can better contribute to the development of a resilient and sustainable economy through technological and other innovations. Better education and job opportunities are especially needed for girls and young women as this has been shown to increase gender equity and standards of living, reduce economic inequality, and promote overall health and wellbeing, all while decreasing fertility rates (Bongaarts and O'Neill, 2018). Lowering fertility rates, which can be facilitated through voluntary family planning, is a major step in climate change mitigation. Additionally, it is critical for climate adaptation given potential future resource scarcity, and the uneven distribution of climate impacts (Stephenson et al., 2010).

The World's developing nations and low income populations are the most vulnerable to climate change. Therefore, reducing inequalities and prioritizing basic human needs for all is an essential component of adapting to and mitigating climate change. Social justice must be integral to climate action since wealthy countries are the greatest contributors to climate change (Fig. 1a) and are the least vulnerable to its negative impacts (Fig. 1b). Now is the time for civil society, government, world leaders and the private sector to act in bold and well-coordinated ways under conditions of a climate emergency. Wealthier countries need to help support both adaptation and mitigation efforts in poorer countries. Transformative change involving integrated adaptation and climate mitigation strategies will yield social and economic resilience and less suffering for humanity as we navigate the uncertainties of the climate crisis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Artelle, K.A., Zurba, M., Bhattacharyya, J., Chan, D.E., Brown, K., Housty, J., Moola, F., 2019. Supporting resurgent Indigenous-led governance: a nascent mechanism for just and effective conservation. Biol. Conserv. 240, 108284.

Betts, M.G., Wolf, C., Ripple, W.J., Phalan, B., Millers, K.A., Duarte, A., Butchart, S.H.M., Levi, T., 2017. Global forest loss disproportionately erodes biodiversity in intact landscapes. Nature 547, 441–444.

Bongaarts, J., O'Neill, B.C., 2018. Global warming policy: is population left out in the cold? Science 361, 650–652.

Buotte, P.C., Law, B.E., Ripple, W.J., Berner, L.T., 2019. Carbon sequestration and biodiversity co-benefits of preserving forests in the western USA. Ecol. Appl. 30, 02039.

Chen, C., Noble, I., Hellmann, J., Coffee, J., Murillo, M., Chawla, N., 2015. University of Notre Dame Global Adaptation Index Country Index Technical Report. ND-GAIN South Bend USA.

Crippa, M., Oreggioni, G., Guizzardi, D., Muntean, M., Schaaf, E., Lo Vullo, E., Solazzo, E., Monforti-Ferrario, F., Olivier, J., Vignati, E., 2019. Fossil CO2 and GHG emissions of all world countries. Luxembg. Publ. Off. Eur. Union.

Daly, H.E., Farley, J., 2011. Ecological Economics: Principles and Applications. Island Press.

Frey, S.J., Hadley, A.S., Johnson, S.L., Schulze, M., Jones, J.A., Betts, M.G., 2016. Spatial models reveal the microclimatic buffering capacity of old-growth forests. Sci. Adv. 2, e1501392.

Global Commission on Adaptation, 2019. Adapt Now: A Global Call for Leadership on Climate Resilience. Global Center on Adaptation and World Resources Institute.

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., Bonn, A., 2016. Nature-based solutions to climate change mitigation and adaptation in urban areas:

perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecol. Soc. 21, 21.
Law, B.E., Moomaw, W.R., 2021. Keeping trees in the ground where they are already growing is an effective low-tech way to slow climate change [WWW Document]. The Conversation. URL 〈https://theconversation.com/keeping-trees-in-the-ground-where-they-are-already-growing-is-an-effective-low-tech-way-to-slow-climate-change-154618〉. (Accessed 22 March 2021).
Moomaw, W.R., Masino, S.A., Faison, E.K., 2019. Intact forests in the United States: proforestation mitigates climate change and serves the greatest good. Front. For. Glob. Change 2, 27.
Mori, A.S., Dee, L.E., Gonzalez, A., Ohashi, H., Cowles, J., Wright, A.J., Loreau, M., Hautier, Y., Newbold, T., Reich, P.B., Matsui, T., Takeuchi, W., Okada, K., Seidl, R., Isbell, F., 2021. Biodiversity–productivity relationships are key to nature-based climate solutions. Nat. Clim. Change 11, 543–550.
Phillips, C., Marden, M., Basher, L., et al., 2015. Forests and erosion protection–getting to the root of the matter. N.Z. J. 60, 11.
Riccioli, F., Marone, E., Boncinelli, F., Tattoni, C., Rocchini, D., Fratini, R., 2019. The recreational value of forests under different management systems. New For. 50, 345–360.
Ripple, W.J., Wolf, C., Newsome, T.M., Barnard, P., Moomaw, W.R., 2020. World scientists' warning of a climate emergency. BioScience 70, 8–12.
Ripple, W.J., Wolf, C., Newsome, T.M., Gregg, J.W., Lenton, T.M., Palomo, I., Eikelboom, J.A.J., Law, B.E., Huq, S., Duffy, P.B., Rockström, J., 2021. World scientists' warning of a climate emergency 2021. BioScience 71, 894–898. https://doi.org/10.1093/biosci/biab079.
Rosenzweig, C., Tubiello, F.N., 2007. Adaptation and mitigation strategies in agriculture: an analysis of potential synergies. Mitig. Adapt. Strateg. Glob. Change 12, 855–873.
Seddon, N., Chausson, A., Berry, P., Girardin, C.A., Smith, A., Turner, B., 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philos. Trans. R. Soc. B 375, 20190120.
Song, C., Lee, W.-K., Choi, H.-A., Kim, J., Jeon, S.W., Kim, J.S., 2016. Spatial assessment of ecosystem functions and services for air purification of forests in South Korea. Environ. Sci. Policy 63, 27–34.
Stahel, W.R., 2016. The circular economy. Nat. News 531, 435–438.
Stephenson, J., Newman, K., Mayhew, S., 2010. Population dynamics and climate change: what are the links? J. Public Health 32, 150–156.
Swart, R., Raes, F., 2007. Making integration of adaptation and mitigation work: mainstreaming into sustainable development policies? Clim. Policy 7, 288–303.
Vincent, J.R., Ahmad, I., Adnan, N., Burwell, W.B., Pattanayak, S.K., Tan-Soo, J.-S., Thomas, K., 2016. Valuing water purification by forests: an analysis of Malaysian panel data. Environ. Resour. Econ. 64, 59–80.