iap SCIENCE HEALTH POLICY
the interacademy partnership

Save the Children

IAP Science Policy Brief

Climate Change Adaptation for Health: Systems-based approaches to formulating solutions and guiding policy

Evidence from case studies

November 2023

Executive Summary

Climate change is a global health crisis with disproportionate effects on vulnerable groups. Building on their previous expertise, the InterAcademy Partnership (IAP) and Save The Children recently initiated a project encompassing case studies worldwide of health adaptation solutions in response to the diverse climate change pathways of risk. The case studies employed systems-based approaches, used transdisciplinary research and involved the producers and users of knowledge working together with a focus on underserved and marginalised populations.

Outputs from this project help to:

- Clarify complex interactions between human-driven environmental change and human health, whether by direct pathways (e.g. heat) or indirect, via ecosystems (e.g. food), or socio-economic systems (e.g. livelihoods).
- Highlight and assess climate-health policy priorities across multiple sectors e.g. urban planning, transport, agriculture in addition to the health sector itself (sections 3, 4.1).
- Advise on the necessity to build resources for generation and application of research findings by policy makers and other end-users, particularly in Low- and Middle-Income Countries, including building capacities and trust at science-policy interfaces, while emphasising throughout the necessary focus on vulnerable, underserved groups (sections 4.1, 4.2 and 4.3).
- Derive shared lessons for health adaptation good practice to guide impact measures for avoiding maladaptation, understanding the limits to adaptation and underpin health system resilience (sections 4.1.3-4.1.6).
- Evaluate issues for transferability and scale-up of adaptation solutions, together with enablers of and barriers to action and longer-term capacity building (sections 4.2, 4.3.3).
- Clarify the intersection between climate change and other health crises e.g. COVID-19 pandemic and other infectious diseases and the implications for global health strategic priorities e.g. Universal Health Coverage (section 4.3.5).
- Show how systems-based thinking provides the conceptual framework and tools for integrating policy actions between sectors and between the various levels of governance, local-national-regional-global (sections 3, 4.3.1).

1. INTRODUCTION TO THE CHALLENGES FOR THE SHARED GLOBAL AGENDA

The pace and extent of environmental changes pose serious challenges to global health gains made over recent decades. Human activities, principally the emissions of greenhouse gases (GHGs) have unequivocally caused global warming (IPCC, 2023). Climate change is a global health crisis as well as an environmental and financial crisis and, among the environmental challenges, climate change is deemed the greatest threat (WHO, 2023).

Climate is one of the principal earth system boundaries (see Rockstrom et al. 2023 for recent update on safe and just earth system boundaries) and climate change has the potential to increasingly disrupt health and wellbeing because, in addition to direct adverse effects on health, it affects the provision of food, safe water and clean air. Human and ecosystem vulnerability are interdependent (IPCC, 2023).

Therefore, climate change adaptation and mitigation planning must not ignore health. Doing so could result in trade-offs and unintended consequences which could ultimately undermine other well-intentioned initiatives to improve health. Actions on climate change are opportunities to reduce and prevent risks to health (WHO, 2020). Addressing climate change and health together is appealing because of the potential win-wins: achieving multiple benefits to human health and the climate (Frumkin and Haines, 2019). Activities in and outside the health sector (e.g. industry, energy production, transport, agriculture) contribute to climate change and, at the same time, affect health. The relationship between climate change and health can be non-linear and involve time delays and feedback interactions among many factors (Whitmee et al., 2015). This complexity can lead to health outcomes which are difficult to predict, including disproportionate adverse effects on children and other vulnerable groups. As a result, as will be described in this Science Policy Brief, a multi-sectoral, systems-based[1], approach is needed to address climate, health and equity together. The purposes of this Science Policy Brief are to: summarise some of the various ways to proceed with adaptation studies and share good practice; help raise awareness of the enablers and obstacles that are common to many of the postulated adaptation solutions, and their implications for policy formulation; emphasise the vital importance of targeting vulnerable groups to tackle health inequalities and climate injustice; and explore opportunities for coordination of policy action across sectors (horizontal integration) and between levels of governance (vertical integration).

The nature, distribution and timescale of the health impacts associated with climate risks differ between countries and within their populations, influenced by geography and socio-economic status, and are rooted in social inequalities. There are commonalities in the deteriorating health outcomes that warrant shared approaches encompassing both climate mitigation and

1 Systems-based approach with cross-sector integration encompasses the complex interactions between natural and social systems and the integration of research outputs from across many disciplines throughout the processes for developing and implementing policy (IAP, 2022).

adaptation solutions. The largest adverse health impacts of climate hazards are in the LMICs and in economically and socially marginalised residents elsewhere, e.g. in urban areas (IPCC, 2023). Health actions taken to identify and quantify solutions must concentrate on the most vulnerable groups and thereby help to ensure deployment of resilient and equitable health systems. Actions must also address the current fragmentation and imbalance in research systems and knowledge uptake.

2. PATHWAYS OF RISK FOR VULNERABLE GROUPS

Health risk is a function of hazard, exposure and vulnerability. There are multiple pathways of direct and indirect risk and multiple physical and mental health consequences (Fig. 1).

While there is still much to be done to quantify risks and their compound effects, there are major global initiatives underway generating an accumulating body of evidence on health effects (e.g. IPCC, 2023; Romanello et al. 2023), their interactions and attribution to climate change. Despite the accumulating evidence, it is still surprising to see how little has been done in the international political arena to combat the health threats posed by climate change (Mogwitz et al. 2022). There is a significant gap between the recognition of the impacts of climate change on health and the actions taken to address it. Access to climate finance for health is a major barrier for building the evidence base and implementing action (Watkiss and Ebi, 2022).

Previous work by the InterAcademy Partnership (IAP), the global network of academies of science, engineering and medicine, using a regional-to-global model, incorporated evidence and perspectives from Africa, Asia, the Americas and Europe (IAP, 2022, Fears et al. 2023). The IAP work has helped to characterise how climate change is bringing serious threats to human health worldwide with the LMICs most vulnerable and children and the elderly amongst the hardest hit and least protected within populations. There is an accumulating research literature on mental and physical health in children and

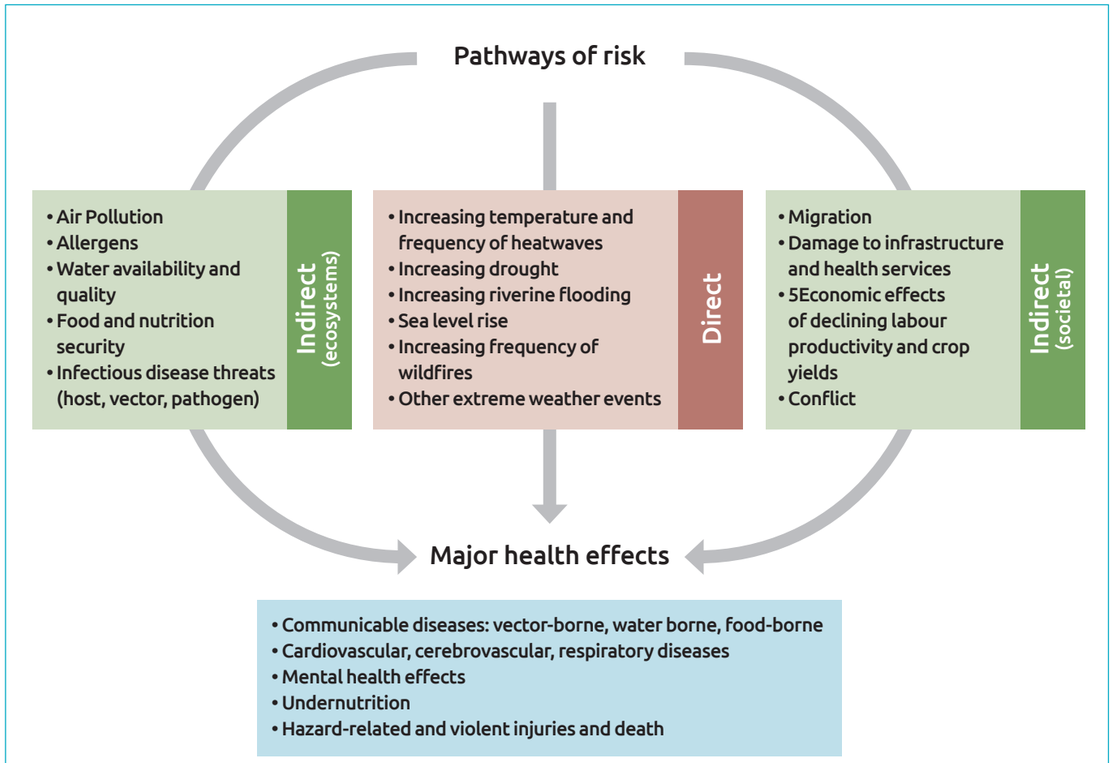

Figure 1. Multiple pathways of risk and health effects. Source: IAP, 2022 report, see further details on the diverse pathways at: www.interacademies.org/project/climate-change-and-health

the disproportionate burdens suffered by them[2]. However, there is much less research on interventions to protect children and the climate crisis should be regarded as a child rights crisis (Save The Children, 2021). The UN Committee on the Rights of the Child recently (UNICEF, 2023) called on states to take action to focus on climate change.

3. IAP-SAVE THE CHILDREN CASE STUDY PROJECT: CO-PRODUCING KNOWLEDGE TO FOCUS ON ADAPTATION SOLUTIONS

Both mitigation and adaptation approaches are needed, and multiple solutions must be better integrated across sectors, but action requires political will and sustained investment. The scientific community has important roles to play first in bringing existing knowledge that is relevant and actionable to the attention of end-users and secondly in generating new transdisciplinary knowledge for feasible, equitable solutions. The widening social and health inequalities resulting from climate change could be reduced or prevented if the drivers and consequences of global environmental change were better understood and if this understanding was reflected in policy and planning.

Mobilisation of both existing and new research outputs to identify solutions can be enabled by:

- Adopting a Planetary Health framework[3] to encompass the health of human populations and the state of natural systems on which human health depends (Whitmee et al. 2015; Pongsiri et al. 2017).
- Executing systems-based research, integrated across sectors to help clarify complex, dynamic interactions, some with unintended consequences, leading to health outcomes.
- Co-producing solutions with end-users, for better understanding of consequences and trade-offs for transformative change.

2 For example, Clemens et al. 2020, Arpin et al. 2021, Hellden et al. 2021, Sahani et al. 2022, Bansal et al. 2023) and on neonatal health (e.g. in Africa, Nakstad et al. 2022) and maternal and foetal physiology (Bonell et al. 2022).

3 Planetary Health is the health of human civilization and the state of the natural systems on which it depends (Whitmee et al. 2015)

To build policy maker awareness of systems-based studies and policies, IAP with support from Save The Children, initiated a Call in 2023 for examples of health adaptation case studies of approaches to problem-solving which have been used to tackle the integrated challenges of climate and health, within the broad context of expanding SDGs, whose current progress is impaired by climate change.

Adaptation is defined by the IPCC as the process of adjustment in natural or human systems to actual and potential climate-led impacts, which moderates harm or exploits beneficial opportunities. Most observed adaptation responses are fragmented, incremental, sector-specific and unequally distributed across regions. Despite some progress, adaptation gaps across sectors and regions will continue to grow under current levels of implementation with the largest adaptation gaps among lower income groups (IPCC, 2023). Adaptation is not a substitute for mitigation, rather mitigation increases the scope for adaptation (IAP, 2022). Climate change adaptation needs as well as capacity to adapt are unequally distributed around the world and this heterogeneity in societies adaptive capacity is often overlooked (Andrijevic et al. 2023).

The design of the IAP-Save The Children case studies project is described in Appendix 1. Table 1 (Appendix 2) brings together the individual case studies to provide some necessary background, but this is intended only to be illustrative of the diversity of approaches taken and serve as an input to the following discussion, particularly on issues for building systems-based approaches to planetary health. Full details on the case studies are published in the collective volume.

4. LESSONS LEARNED FOR DEVISING AND IMPLEMENTING ADAPTATION SOLUTIONS: WHAT IS IMPORTANT FOR RESEARCHERS AND POLICY MAKERS?

The following sections draw on material in the case studies and workshop discussion to seek to answer three questions:

- What are the issues to consider when designing effective climate-health adaptation studies?
- What is the role of case studies as a basis for developing specific recommendations for adaptation policy and practice?
- How can systems-based adaptation approaches help to build action at science-policy interfaces?

4.1 Designing effective adaptation approaches

In answering the first of these questions, it should be appreciated that adaptation encompasses technological, behavioural, institutional, economic and societal approaches. Published literature on the planned measurement of adaptation impacts as an endpoint in research in LMICs is particularly limited (Scheelbeek et al. 2021) and the IAP aggregated case studies resource are proving valuable in helping to catalyse discussion on some key conceptual and methodological points. There are several principles that need to be considered when devising and implementing adaptation plans for reasonable prospect of success in informing policy and practice. These critical success factors include:

4.1.1 Cross-sectoral integration

Health adaptation is not a matter for the health sector alone but is also relevant to climate action objectives for many other sectors, e.g. urban planning, transport, agriculture, and tourism, as unplanned and uncoordinated development in these sectors may have deleterious effects on the health sector. Collating research across sectors and disciplines facilitates systems-based thinking as exemplified by the case study on integrated modelling-based conceptual frameworks (Bassi). The complexity and fluidity of system dynamics requires a continuing commitment to input new data, reinforcing the prerequisite to establish active transdisciplinary networks and involve end-users. Omission of a cross-sectoral perspective means that adaptation costs are often underestimated and the omission of human health as a key sector is particularly problematic (Adaptation committee synthesis report, UNFCCC, 2022).

Case studies demonstrated how cross-sectoral integration may be tailored to local circumstances e.g. in community-led initiatives and may combine adaptation and mitigation actions, particularly when the latter bring early health co-benefits to the local community (e.g. Limaye for reducing urban fossil fuel combustion and air pollution; Eshetie for urban overheating; Kamaruddin for implementation research on a nationally-led action plan) although combined actions raise additional challenges for quantifying specific interventions.

This complexity in assessment of multiple actions is also exemplified by an infectious disease intervention study (Rahman, on dengue) where aggregation of all usual prevention and care practices complicates the possibility of distinguishing between those that are effective and ineffective in a composite endpoint. More precision in differentiating between both drivers of risk and enablers of success enables advice to be generated that will be applicable to other settings.

4.1.2 Triple wins for health, equity and environmental sustainability

Adaptation solutions should be prioritised if they are value-creating and sustainable in the longer-term, avoiding allocating support to prolonging the life of practices and business models responsible for high GHGs and excessive resource consumption. Case studies demonstrate that adaptation findings often have implications for private sector as well as public sector innovation (e.g. Canales Holzeis, Mugiyo, improving agriculture) and for livelihoods and justice as well as for health and the environment. Pursuing triple win objectives may create tension between the local community's evidence-based views and the less granular evidence and assumptions used by policy makers at larger scale (e.g. Pratt, land use considerations for physical and mental health of Indigenous Peoples; see also Howard, Sali, Bassi). Using a systems-based approach improves the likelihood that knowledge accumulated, maps and tools generated, can be accepted as valid by all involved. While the triple win is the ideal, not always attainable, science-based policy solutions should always consider trade-offs, side effects and unintended consequences during adaptation approaches.

4.1.3 Measuring impacts

Case studies reinforce the point that the evaluation and attribution of adaptation interventions is challenging. Unlike mitigation, where the effectiveness of policy can be measured in terms of GHG emissions reduced, there is no universally accepted metric for adaptation. Many approaches tend to use surrogate or intermediate outcome indicators rather than final impact metrics and measures of sustainable effect. These surrogate/short-term measures may be unconvincing to policy makers, health practitioners and the public, and may require further validatory research. For example, "particulate matter" may be a proxy indicator for specific air pollutants that need to be distinguished in ongoing research (Saldiva).

It is good practice to agree a quantifiable endpoint (as well as standards set and classifications used) at the start of the intervention otherwise there is risk of maladaptation (see later) or of premature confirmation of success without having fully considered alternative options (Nowreen, engineering solutions for water quality). Selection of quantifiable endpoints has been rare in the published literature, especially for LMICs, and demonstrable effects tend to be fragmented and incremental rather than transformative (Berrang-Ford et al. 2021). End-users should be involved in identifying endpoints and this may then require combining diverse knowledge sources, e.g. the lived experience of Indigenous People (Pratt) where there is risk of disconnect between the established land rights of the local community and policy maker sustainability objectives. The necessary involvement of populations at risk is reinforced by findings from a recent published case study relating to sea level rise and the potential inhabitability of certain areas (Farbotko et al. 2023), where it was observed that policy maker assumptions may constrain debate about alternative climate adaptation futures and, thereby, pre-empt options.

Many of the case studies discuss practical difficulties in evaluating success of an intervention (e.g. Wright for 1º health care system resilience). As part of societal valuation of success, cost-benefit assessment is even more demanding but has the potential to exert durable influence on policy making over multiple policy domains. Overall, health benefits are non-negligible even if often intangible from a financial perspective (Bassi).

4.1.4 Maladaptation

Without impact measurement, it is difficult to know whether an intervention is appropriate for sharing as good practice more widely or, indeed, if the intervention may worsen the situation by inadvertently reinforcing, redistributing or creating new sources of vulnerability, especially affecting marginalised groups (IPCC, 2023). Maladaptation is more likely if there is weak understanding of the drivers of risk, and inadequate or inequitable end-user participation in design and implementation of the adaptation action (perhaps because of "top-down" retrofitting the intervention into existing development agendas) and a lack of critical engagement with how success is defined. Arguably, however, adaptation and maladaptation outcomes should be regarded as part of a continuum rather than as absolutes (Reckien et al. 2023). Case studies indicate that co-production of knowledge-based approaches are more likely to generate equitable adaptation and engaging the local community in the implementation strategy minimises the risk of maladaptation (e.g. Howard, marginalised communities at risk of flooding).

4.1.5 Limits to adaptation

Strategic limits may be self-imposed by lack of ambition in scope both for research and policy formulation. Other limits may be physical, behavioural, technological or financial (IAP, 2022) and case studies show that competing health priorities may also limit climate adaptation capacity (e.g. Guinto). The potential for adaptation may be limited by weak intersectoral collaboration and by inadequate infrastructure, such that external funding cannot be spent effectively, risking maladaptation (Hounkpatin). Adaptation limitations are important potential determinants of climate damage and hence further increase the case for mitigation.

Pilot studies can help to reveal ways of addressing limits to adaptation. For example, the financial constraints experienced in the case study on pioneering plant breeding programmes indicates the need to develop new partnerships to scale-up interventions and generate sufficient quantitative evidence to demonstrate impact at scale (Canales Holzeis). A similar conclusion can be reached for capitalising on other new technologies (such as machine learning in peatland management, Sali).

4.1.6 Health system resilience

A broad operational framework for building climate-resilient health systems has been developed by WHO and this guidance helps guide health professionals and other health-determining sectors such as nutrition, water and sanitation. In conceiving plans for better resilience, it is valuable to integrate health into alternative socio-economic futures (shared socio-economic pathways, SSPs, Seller 2020) and approaches to quantifying adaptive capacity within the SSPs framework have recently been discussed (Andrijevic et al. 2023). Case study experiences illustrate how socio-economic inequalities limit development of resilient systems (e.g. marginalised mothers and children, Wright; heat-health impacts of urbanisation, Kamaruddin, Saldiva).

While LMICs have many pressing needs to build resilience, it is important in formulating practical policy options to focus on what is actionable as well as what is aspirational. Health systems face other global challenges (e.g. COVID-19 and HIV, Guinto) and decision-makers will have to consider the priorities for attaining climate change resilience within the more general resilience required for health systems.

4.2. Role of case studies to develop specific recommendations to improve adaptation approaches

Evidence from the case studies helps to substantiate the precept that linking environmental change with human health relationships can inform planning for, monitoring, and managing the health risks of changing environmental conditions over time. Case studies also have an important role in hypothesis generation and catalysing further research and, in answering the second question asked in the first part of section 4, it is important to emphasise that, for operationalization, policy recommendations must be specific. This specificity is discussed in the published collection of case studies and Box 1 summarises some of the practical points for developing specific recommendations from case studies or other initial research.

BOX 1. Enhancing the value from initial research studies: guidance for researchers, funders and those involved in research policy

The quality and relevance for enabling further work is enhanced if:

Specific attribution of an adverse health impact can be made to a causal climate change pathway.

Intervention design is tailored to the needs and complexities of the study population, and study limitations are recognised (such as uncertainties in data, model sensitivity).

Measurable indicators of adaptation success are agreed in advance and selected to be convincing to decision-makers (such as policy departments, public health authorities, education systems).

Recommendations from data-driven assessments, including proposed criteria for upscaling, are realistic and actionable by decision-makers and other end-users considering, where necessary, their other priorities and capacity limitations.

Recommendations directed to the scientific community itself, include advocating for more robust data and emphasising the need to incorporate ethical considerations such as when collaborating with local communities and, more generally, regarding privacy and security of data collected.

4.3 Building action at science-policy interfaces

While there are many knowledge gaps to fill by new transdisciplinary research and more effort is needed to integrate data sets (e.g. between climate risk and health impact), it is urgent to act on the evidence already available and to bring interventions to scale. The major obstacles to clarifying adaptation solutions and using these more widely have been extensively discussed by other bodies (e.g. IPCC, 2023) and include limited resources, lack of private sector and citizen engagement, insufficient mobilization of finance, low climate literacy, lack of political commitment, limited research and slow uptake of research outputs, and low sense of urgency. These impediments will not be discussed in detail here but, instead, space is given to review of key issues from case studies for supporting and capitalising on the science-health policy interfaces, informing both policy development at various levels of governance, and its implementation by regulatory authorities and others.

What then, to answer the third question asked in the first part of section 4, were the recurrent themes for policy (Fig. 2) emerging from the workshop discussions? The following sections provide further clarification.

4.3.1 Systems thinking

Increasingly, the link between science and policy requires integration of differing forms of knowledge, transcending disciplines and sectors, bringing together commensurate evaluation of costs and benefit, and clarifying facilitators and obstacles to action. Progress depends on better understanding of the drivers of risk and better targeting of interventions to the most vulnerable. The case studies have provided multiple entry points for developing systems thinking to refine risk assessment and targeting actions, e.g. by combining urban heat maps, socio-economic variables and health impacts, combining agricultural land drought distribution maps, data on underutilised crops and nutritional values. Moreover, case studies underscore the value of systems-based approaches not only to research communities but also to policy communities to reform

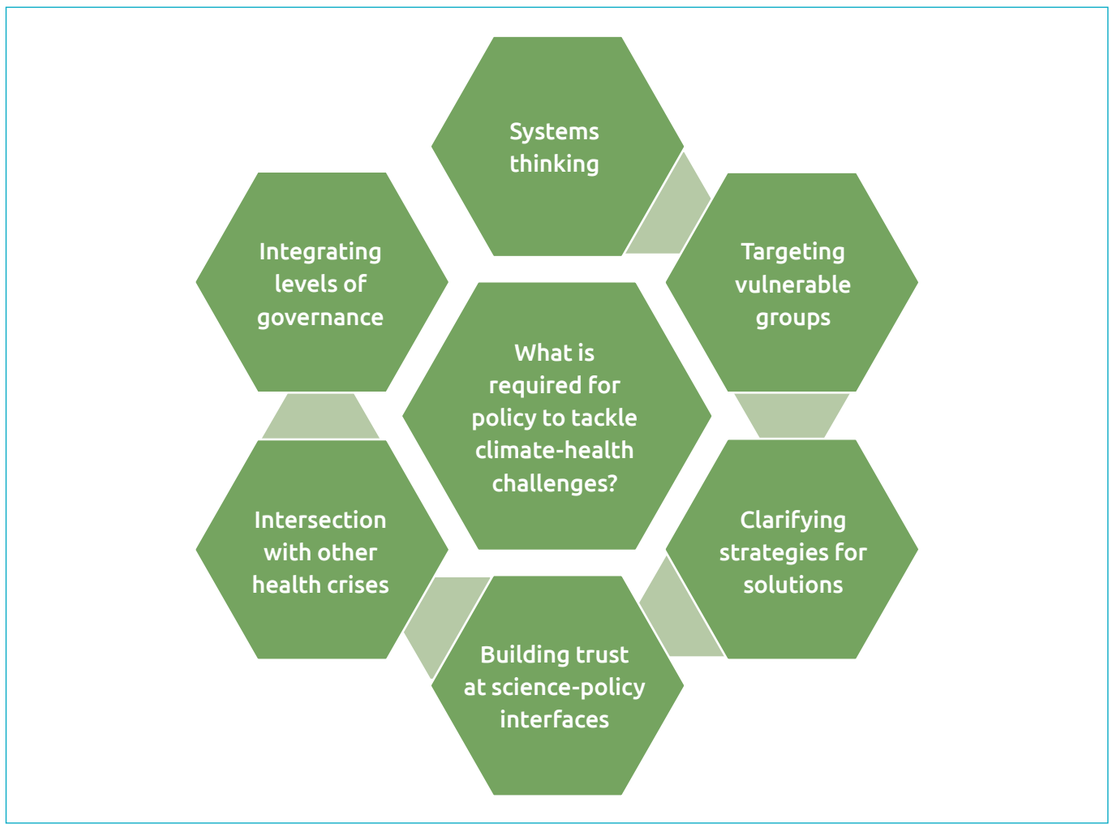

Figure 2. Strategic aspects of policy opportunities and challenges, and their interconnections emerging from workshop discussion

current governance weaknesses. These disconnects include, for example, where Environment and Health Ministries operate in isolation and where public research is funded without also having in place a flexible and evidence-based regulatory system that encourages innovation.

4.3.2 Targeting vulnerable, underserved groups

As noted in AR6 (IPCC 2023), prioritising equity, climate justice, social justice, inclusion and just transition processes can enable adaptation and mitigation actions and climate-resilient development, leading to more sustainable outcomes, reduction in trade-offs and supporting transformative change. Drawing on the perspectives of human rights and climate justice, case studies articulated concerns for women and children and the elderly, recognising also that there is more work to be done to elucidate the drivers of vulnerability. For example, children may be vulnerable because of their disproportionate exposure to a hazard but also because of linkages between adverse health and malnutrition and the greater impact of a hazard if biological functions are not yet fully developed.

As noted previously, vulnerability and inequity can be exacerbated by maladaptation and, as this is frequently associated with externally driven initiatives (despite good intentions), involving the local community in co-production of knowledge and its utilisation must become a core part of equitable adaptation strategies. It was described previously how attempting adaptation without understanding the local drivers and distribution of risk often worsens vulnerability. Does this prerequisite for more knowledge conflict with the urgency to act now? Additional safeguards can be adopted to minimise the possibility of maladaptation, e.g. by management of the implementation strategy within the local community while, at the same time, accelerating political will to target those most vulnerable.

Addressing the needs of vulnerable groups must consider the probability that their needs may be qualitatively

as well as quantitatively different. For example, a standard classification of the categories for heat-health risk has been constructed for otherwise healthy, adult populations and will be different for children. Therefore, the accumulating evidence base must be used to inform risk taxonomies and standard setting as well as proposed adaptation solutions.

4.3.3 Progressing adaptation solutions

Case studies can help to furnish proof-of-principle for an adaptation intervention but their deployment, upscaling of interventions and integration with other actions may well require policy support. Researchers need to consider when in the policy cycle it is most appropriate to seek such support, that is when will decision-makers be most receptive to the evidence? Timeliness was exemplified by case studies discussing the opportunity to inform standards and guidelines that are already in early development. Experience from pilot studies may also help to make the health case for combining adaptation and mitigation strategies within an intervention. For example, objectives for crop breeding to modify legume traits can include reduced cooking time (hence introducing a health co-benefit of reduced biomass combustion) as well as the increased agricultural productivity and resistance to biotic and abiotic stresses.

Solutions can be made more specific if there is better understanding of the drivers of risk for vulnerable groups. Nonetheless, many of those who are most vulnerable to climate change will likely suffer several adverse health impacts, necessitating action to reduce social and other inequalities between and within countries alongside specific adaptation solutions. Compounding the adverse consequences of anthropogenic climate change are broader socio-economic disparities, and discrimination and the legacy of imposed borders, all also anthropogenic in origin and requiring to be tackled.

Resolution of the many complexities for LMICs requires support by increased international funding, albeit using local knowledge to make best use of external sources. Therefore, enabling conditions must be created for adaptation to increase access to mobilization of financial support from both domestic and international funds (Adaptation committee synthesis report UNFCCC, 2022) and these depend on capacity building and new governance mechanisms to integrate adaptation considerations into macroeconomic and fiscal policies.

4.3.4 Building trust for formulating policy

Translation of research outputs into facilitative policy and practice depends on resources, capacities, priorities and credible evidence, and the case studies identify

multiple priorities for building and using the knowledge base in LMICs. Translation also depends on enabling trust between the knowledge-generating and policy-making communities. For the translation process to be trusted and effective, policy makers must be receptive to diverse sources of evidence that may be unfamiliar to them (and initially disregarded). Mention has already been made, for example, of the problems faced by Indigenous Peoples in engaging with policy makers about land use rights, and it is a continuing responsibility and accountability for all involved in evidence generation to ensure validation of its robustness, relevance and attributability. Lessons of good practice testify the value of pro-activity, that is knowledge producers initiating contact with policy makers well in advance of providing evidence to ask “how can we help” as part of designing the scope of the research.

Maintenance of trust is also important for implementation research to monitor outcomes of policy decisions, with feedback for future policy development. This continuing role likely requires researchers to build trust with additional parts of the public governance mechanism, such as law enforcement, where valuable insight is being gained from the case study experience in Malaysia (Kamaruddin). Another recent, published, example of the importance of law enforcement to implementation of climate change goals is provided from Amazonia (Gatti et al. 2023) where a decline in law enforcement has led to increases in deforestation and biomass burning, which increase GHG emissions, and lead to drying and warming of the Amazon forests.

4.3.5 Intersection with other health crises

Climate change is occurring at a time when there has been, and will continue to be, concurrent health crises, e.g. the pandemic (COVID-19) and other major infectious disease threats (e.g. HIV, MERS, Zika virus, Baker et al. 2022). Systematic assessment shows that more than half of known human pathogenic diseases can be aggravated by climate change (Mora et al. 2022), which also increases cross-species viral transmission risk (Carlsson et al. 2022), driving new zoonoses. These complex infectious disease interactions require policy coordination (IAP, 2022).

Direct health effects of climate change also intersect with the adverse health consequences of other climate change risk pathways e.g. exacerbating food and nutrition insecurity (Jameel Observatory et al. 2022). Furthermore, specific policy recommendations to address the adverse health impacts of climate change must be set into the context of existing, agreed, global health goals, in particular Universal Health Coverage and within existing broader frameworks, in particular Sustainable Development Goals (SDGs). A recent report from UNDESA and UNFCCC (2023) emphasises the importance of tackling the climate and sustainable development crises together, because the Paris Agreement goals and SDGs are mutually reinforcing. However, UNDESA/UNFCCC also highlight the need for faster progress in integrated planning and implementation to address knowledge, institutional and economic barriers, a conclusion that is consistent with the emerging messages from the present case study work.

At the same time as facing these multiple pressures, health care systems have a responsibility to reduce their own carbon footprint. While much can be done for this objective in the 1º and 2º health care facilities themselves – as committed in the WHO COP26 initiative – more can be done within a supportive policy framework for decarbonisation in the health sector (IAP, 2022).

4.3.6 Integrating levels of governance

Decisions taken in one country or locality can affect neighbours by disseminating risks more widely, including across borders (for example, air pollution, infectious disease, forced displacement). Policy decisions may also have worldwide implications e.g. development of new regulatory frameworks to manage innovation that can have international trade consequences and thereby impede export of innovation from LMICs. However, as noted in several of the adaptation case studies, regional and local implications are often overlooked in national plans.

IAP (2022) has previously discussed in detail the issues for connecting and managing across levels of governance local-national-regional-global, each level characterised by policy strengths and weaknesses. For example, centralised global health initiatives may become detached from local realities in diverse settings. This problem may be compounded by fragmentation and disconnects between local/national and global levels for utilisation of scientific evidence. Regional cooperation has the potential to act as a bridge and thereby spur the necessary actions to integrate implementation, risk communication and capacity building (Shabana et al. 2023) in addition to informing global initiatives customised for relevance to local settings (Fears et al. 2023) and linkage to SDGs. However, over the passage of time, multiple regional institutions have come into being, often with little reference to one another and there must be better inter-institutional coordination to avoid duplication and strengthen accountability.

5. CONCLUDING POINTS

There are unprecedented health threats but there are now also unprecedented opportunities to use scientific evidence and other knowledge to generate and evaluate solutions. Climate change is an emergency and health crisis which requires urgent, concerted and equitable action. Underscoring all the lessons brought forward in this Science Policy Brief is the need to build resources in LMICs to generate and translate research to policy and practice. The case studies presented in the collective volume from this project ranging across a diversity of themes and methodologies can help both hypothesis generation and show the value of the systems-based approach to understanding and tackling some of the major challenges for climate change and health.

Quantifying the human health impacts of global and local environmental change can help policy makers internalize health issues across multiple policy domains and, thereby, set priorities. And understanding how the social determinants of health intersect with environmental change reveals the fuller context for identifying a range of interventions which target the important, modifiable factors. By identifying key policy trade-offs and unintended consequences, systems-based approaches inform climate adaptation strategies involving multiple sectors, and within the broader SDG context.

The visibility of climate change impacts on health is beginning to increase in the broader policy deliberations. COP28 and its follow-up provides an important opportunity to take forward health adaptation priorities.

Appendix 1

In this new IAP work supported by Save The Children, priority was given to:

- Food systems and agriculture.
- Energy, including production, distribution, access and efficiency.
- Urbanization, including urban planning.
- Health systems strengthening

particularly when focusing on underserved groups such as women and children and where addressing a policy problem from the outset.

IAP invited case study proposals to:

- Describe the climate-health relationship of interest and the policy objective to inform solutions for sustainable development and public health.
- Specify the geographical location/spatial scale and population at risk.
- Help clarify the probable causal pathway by which climate variability affected health risk.
- Employ specific indicators to measure outputs, accounting for and, if possible, avoiding unintended consequences.
- Consider opportunities for replicability of impacts, upscaling and generalisation to other contexts; exploring enabling factors and obstacles for policy application more widely.
- Take account of disproportionate impacts of climate change on vulnerable and underserved communities and embed study outputs into longer-term capacity building.
- Ensure robust study design (whether qualitative or quantitative), including multidisciplinary teams, systems-based approaches, recognition of uncertainties in data bases, and engagement with end-users in production and application of findings.
- Address multisectoral impacts of climate change, potential policy synergies across sectors and trade-offs among the array of effects of choices made.

The case studies submitted to IAP were peer-reviewed by a global group of experts and the successful proposers invited to a workshop hosted by IAP in Trieste, Italy together with peer-reviewers, selected to ensure geographical balance in the further discussions. Following the workshop, revised full-length case studies were sub-edited for consistency of format and published as a freely accessible collection by IAP.

Appendix 2

Table 1. Summary of case studies. See individual studies in the collected volume for detail on objectives, methodologies and outputs. To be succinct, this Table focuses on only a small number of the issues for developing good practice in future systems-based approaches (final column) – the individual case study publications provide much more detail.

LEAD AUTHOR	MAIN STUDY LOCATION	ADAPTATION GOAL IN RESPONSE TO CLIMATE CHANGE	RESEARCH METHODOLOGY	INVOLVEMENT END-USERS	SELECTED OBJECTIVES FOR FUTURE BUILDING OF SYSTEMS-BASED APPROACH
Canales Holzeis	Sub-Saharan Africa and India	Improved legume traits for food and nutrition security (FNS) as part of climate-smart agriculture	Marker-assisted selection for molecular breeding	Smallholder farmers, national legume breeders, student training	Evaluating options for partnership for upscaling action to maximise impact of pilot studies and enable policy development
Pratt	Pgak'yau Indigenous community, Thailand	Human and ecosystem health in traditional farming community	Trans- disciplinary-based workshops, interviews, land-use surveys	Indigenous community, NGOs	Reconciling land-use needs (importance of traditional rotational farming) by greater valuing of local knowledge sources
Nowreen	Dacope, Bangladesh	Tackling water scarcity and pollution for improving farming productivity	Field-based applied research on Aquifer Storage and Recovery technology	Local farmers and authorities	Proof-of-concept demonstrated; engineering work should now aim to integrate other disciplines to tackle specific climate-health challenges
Limaye	Ahmedabad, India	Integrating adaptation (cool roofs) and mitigation (substituting renewable energy) for coal-fired power stations	Modelling study based on local heat and health data	Results provided to local city, State, National government	Basis for assessing local exposure, adding other interventions, targeting vulnerable groups
Eshetie	Addis Ababa, Ethiopia	Identifying urban heat risk areas for targeted intervention	Geographic-weighted regression tool to map urban overheating	To advise city authorities (both to target interventions and inform city expansion)	Land surface heat maps now need to incorporate health impact assessment and target most vulnerable communities
Mugiyo	KwaZulu-Natal, South Africa	Assessing potential for expanding use of neglected, underutilised crops in marginal areas for FNS	Machine learning to model nonlinear relationship between variables under different scenarios	Smallholder and commercial agriculture implications but needs further practitioner validation	Modelling improved by including nutrition and health impact assessments and refined for onset, duration and cessation of drought
Kamaruddin	Kuala Lumpur, Malaysia	Health solutions for urban heat islands	Trans-disciplinary research and modelling assessing Kuala Lumpur Action Plan 2050	NGOs, private sector, cross-sectoral policy makers plus civil focus groups	Underscores importance of implementation research to evaluate actionable policy across governance mechanisms e.g. law enforcement sector
Rahman	Dhaka, Bangladesh	Surveying and promoting dengue fever community awareness	Convenience sampling, survey-based, behaviour intervention study	Subjects recruited from local community	Quantification improved by more precision in determining risk drivers, clear measures of success and involvement of health sector
Saldiva	Sao Paulo and other Brazilian cities	Assessing heat and pollution impacts in urban areas	Correlating data on heat, air pollution, health (taking account of lag times in effects)	Future contacts to be enhanced by simplifying presentation of outputs, involving community in co-design	Data sets are major resource to understand urban variation and risk association with social determinants.
Howard	Tamale, Ghana	Understanding and managing urban flood risk in vulnerable, underserved communities	Co-produced, trans-disciplinary with interviews, workshops plus use of hydrological sensors	Local and traditional authorities, NGOs and communities emphasising transforming end-user to active participant	Can capitalise on key lessons for co-production for equitable adaptation, with designed inclusivity, and clarifying drivers of risk
Sali	Malaysia	Developing real-time alerts for peatland fire haze	Machine learning (Internet of Things) for systems-based prediction of soil parameters	Local farmers provide feedback on how much data is usable by community	Potential for integrating goals for mitigation and adaptation requires better coordination with health data and across government
Guinto	Coastal towns, Philippines	Building climate-resilient health systems, e.g. for water-related diseases	Trans-disciplinary follow-up to municipal plans, for training, intervention and priority setting	Initial involvement of mayors and health authorities, ongoing contact with health professions	Basis for increased climate awareness by engagement with health services and other sectors
Wright	Multiple districts in South Africa	Clarifying determinants and improving heat-health resilience in 1° health care settings for mothers and babies	Trans-disciplinary assessment of heat-health vulnerable settings	Increasingly coordinated with multiple NGOs, UN bodies plus local, provincial authorities	Upscaling use of developed assessment tools and guidelines depends on building sustained relationships for trust in quality and relevance of advice
Hounkpatin	Benin	Evaluating scope and priorities for climate and health in recently published National Adaptation Plan (NAP)	Evaluation of NAP using additional data sources, in terms of context, process and content	End-users had only limited involvement in NAP preparation	NAP demonstrates awareness of climate-health but coverage needs to be more systematic and reflect complexities for vulnerable groups and across sectors
Bassi	Somalia (health-food-climate), Pakistan (urban tree planting), Sri Lanka (multiple sectors), Laos (WASH)	Using systems dynamics modelling to estimate health benefits of climate action	Qualitative, quantitative and cost-benefit modelling e.g. Causal Loop Diagrams, based on multiple research streams	Co-creation of methods with WHO etc. Impacts discussed with policy makers, private sector, civil society	Provides proof-of-principle for integrated modelling but need to address concern that complexity of outputs hinders advocacy for targeted solutions

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IAP Science Policy Brief
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SYSTEMS-BASED APPROACHES TO FORMULATING SOLUTIONS AND GUIDING POLICY

The initial draft was prepared by **Robin Fears** in discussion with **Montira Pongsiri** (Save The Children) and **Peter McGrath** (IAP), peer reviewed by three experts, then endorsed by IAP.

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