The Unfinished Research Agenda in Adaptation

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KEY MESSAGES

- Adaptation is a complex and multifaceted subject that is evolving rapidly as climate change impacts the world in ever more challenging ways. Hence there is a large research agenda to fill in present and future knowledge gaps on adaptation, spanning the disciplines of climate science, economics, psychology, and other social sciences.
- For adaptation to be effective, it requires knowledge of current and future climate-related risks. However, there is a dearth of climate risk data and models for actors seeking to invest in adaptation, particularly at a more granular level. One of the most important but difficult challenges is to gain a better understanding of adaptation to more extreme forms of climate change, such as those associated with 3–4°C of mean surface warming.
- The effectiveness of strategies for adapting to climate change depends on the social acceptability of options for adaptation, the institutional constraints on adaptation, and the place of adaptation in the wider landscape of economic development and social evolution. Research needs to contribute to an understanding of all three.
- Collective action is at the heart of many decisions regarding the management of natural resources,

which are a key locus of adaptation. Greater insight can be gleaned on how collective action is central to adaptive capacity at various scales by case-specific research.

- At the local level, adaptation preferences across the African continent have been found to be rather heterogeneous and conditioned by a host of social factors. In addition, the adaptation strategies perceived to be most effective were those that addressed underlying drivers of vulnerability, rather than those that focused on climate change alone. Further research is required on adaptive behavior at the local level.

> **We need the signals that Glasgow meant something, that Paris is alive, that hope is alive, that 1.5 degrees is no longer hanging by a thread, that the evidence and the science, most importantly, the lives that have been lost, the livelihoods and the property that has been lost in Africa really does demonstrate the reality for over one billion people in jeopardy. So let's use this moment for a reset for Africa, and for the world, and for our future generations."**
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> **Amina J. Mohammed**
> Deputy Secretary-General of the United Nations

INTRODUCTION

Climate change poses risks to land-based food security, water security, urban systems, terrestrial biodiversity, and more.[1] Some risks are particularly relevant for individual regions while others are global. Climate change is expected to reduce renewable surface water and groundwater resources in most dry subtropical regions, possibly intensifying competition for water among sectors. Water stress is already a major issue in many countries around the world.[2]

Climate change is expected to affect agricultural production and further undermine food security. For wheat, rice and maize in tropical and temperate regions, climate change without adaptation will negatively impact production for local temperature increases of 2°C or more above late 20th century levels, although individual locations may benefit. Temperature increases of about 4°C or more above late 20th century levels, combined with increasing food demand, are expected to pose large risks to food security globally, with reductions in maize and wheat yields reaching up to 50 percent for many countries across Sub-Saharan Africa.[3]

The risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems. Countries in Sub-Saharan Africa are particularly vulnerable to climate change because multiple biophysical, political, and socioeconomic stresses interact to heighten the region's susceptibility and constrain its adaptive capacity. The risk of climate-related impact is geographically heterogeneous. Flood risk is most prevalent in southwest Africa and countries with large rivers in West Africa, fueled not only by increasingly extreme hydrometeorological activity, but also by deforestation and urban encroachment in flood plains.

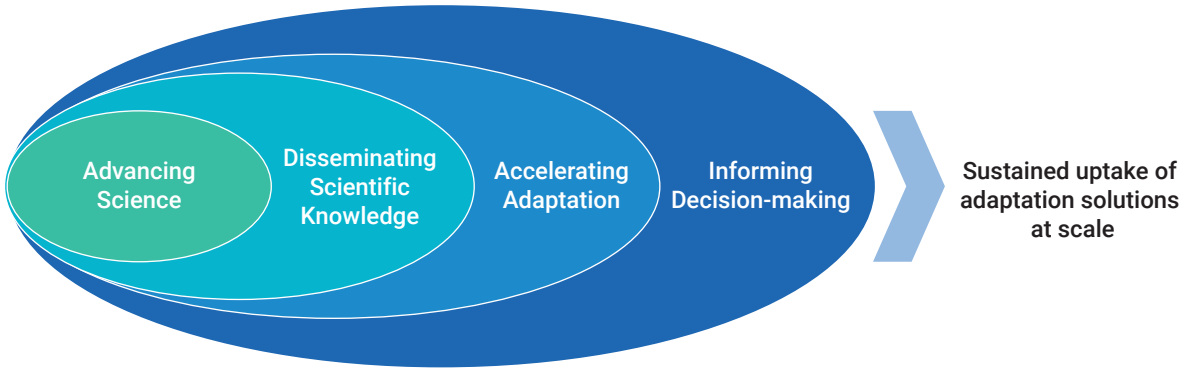
Sea-level rise is of particular concern in low-lying coastal areas, increasing flood frequency and risk of storm surge. This is of special concern given that half of the African settlements with 1–5 million inhabitants are located in low-elevation coastal zones, with some estimating that Africa's populations in low-elevation coastal zones will rise at more than double the world's average.[4] Extreme heat is particularly problematic because many cities in Africa have very little green space, leading to an increased heat island effect. Tropical cyclones, whereby one singular event can have a globally catastrophic impact, are also of concern. The livelihoods of 70 percent of Africans are dependent on rainfed agriculture, an activity that is characterized by small-scale, subsistence farms that are vulnerable to a variety of stresses, including those associated with climate change.[5]

Adaptation, defined by the Intergovernmental Panel on Climate Change (IPCC) as "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities,"[6] is needed to manage current climate impacts and will be increasingly vital as the world continues to warm. Adaptation can take place at a number of scales, from local to global, addressing climate-related problems at that particular level, and making use of capacities available to that particular group of actors.

Since climate is inherently variable, human societies have always and everywhere had to develop coping strategies in the face of unwelcome variations in climate or weather extremes. Pastoralists in the West African Sahel, for example, have adapted to cope with rainfall decreases of 25–33 percent in the 20th century. Progress in adaptation planning and implementation has been observed across all sectors and regions, generating multiple benefits. However, adaptation progress is unevenly distributed with observed adaptation gaps. Also, many initiatives prioritize immediate and near-term climate risk reduction. To increase the efficiency and effectiveness of adaptation, integrated, multisectoral solutions that address social inequities, differentiate responses based on climate risk, and cut across systems are vital.

Research has a central role to play in achieving the transformational adaptation outlined above. However, it needs to go beyond assessing risks and identifying impacts and instead take a problem-focused and systems-oriented approach, pursuing user-centered solutions with a clear line of sight between research and its application. Figure 1 visualizes the theory of change of adaptation research for impact.

Figure 1. Theory of Change of Adaptation Research for Impact



ADVANCING SCIENCE AND DISSEMINATING SCIENTIFIC KNOWLEDGE

For adaptation to be effective, it requires knowledge of current and future climate-related risks. As an example, when planning for the coming season, a small-scale farmer might want to know when the rains are likely to start, and how long they are likely to last. Groundwater baseline data, 24–48-hour precipitation data, and forward-looking climate projections are key to determine what to plant and when to plant it in order to ensure optimal production. As another example, when planning a water storage and distribution system to ensure availability for a growing urban population, a government ministry will want to know where it should construct a dam and the associated infrastructure, and what their design should look like in order to ensure maximum efficiency and reduce the risk of losses or excessive maintenance and repair costs due to floods and drought.

Or consider the problem of coastal resilience, which needs to be understood before it can be solved. Erosion hotspots must be identified to inform the planning of actions to reduce erosion. Given the dynamic nature of coastal accretion and erosion processes, site-specific research and solutions are required. Hotspot identification requires monitoring and computational modeling of coastal morphology, sediment flows, and fluid mechanics as well as the impact of coastal developments in many locations. As another example, consider a country's National Adaptation Plans, which are supposed to direct investments toward strengthening the capacity of countries to cope with climate shocks. However, investments do not only need to help in coping with current and past shocks but also adapt to ongoing climate change trends. So, policymakers would need to know what to expect in the next 10, 20, or 30 years.

There is a dearth of climate risk data and models for actors seeking to invest in adaptation, particularly at a more granular level. Research also needs to provide insight into the conditions of vulnerability and exposure. The vulnerability to climate risk of individuals and of societies is determined, not only by the likely responses of the resources on which individuals depend, but by the availability of resources and, crucially, by the access of individuals and groups to these resources. This is well documented across a wide range of political and economic circumstances and development processes.

Vulnerability is thus a socially constructed phenomenon influenced by institutional and economic dynamics. As an example, on average, 60 percent of urban residents in Africa live in informal settlements.[7] In these settlements, existing vulnerabilities due to the lack of adequate income and assets, infrastructure, basic services, and voice in governance are further exacerbated by the degradation of ecosystems and habitats and climate change–related disasters and stresses.

Conducting vulnerability assessments and providing local climate projections can help formulate a clear climate rationale and identify where adaptation is needed the most. Informality characterizes a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significant portion of urban and rural economies across the African continent and must be understood if climate adaptation activities are to be effective. One of the most important but difficult challenges is to gain a better understanding of adaptation to more extreme forms of climate change, such as those associated with 3–4°C of mean surface warming. It is clear that those higher levels of warming could be extremely disruptive and adaptation strategies would have to change, perhaps fundamentally so. The empirical analysis is by design restricted to the relatively modest levels of climate variability observed in the recent past. Artificial intelligence is increasingly being used to expand the realm of future climate scenarios.

Researchers need to ensure that scientific knowledge is packaged in a comprehensible manner and disseminated to the broader public. Knowledge sharing among different stakeholders will help reduce transaction and information costs and involve the public and private sectors in identifying vulnerabilities as well as adaptation solutions. Data collection and analysis can also be empowering. Involvement of communities in data gathering and GIS mapping can help them to understand and articulate their needs and challenges better, and to negotiate more effectively with governments.

UNDERSTANDING ADAPTATION CONTEXTS

The diverse impacts of climate change and adaptation responses affect societies in numerous ways, including where and how food is produced and how water bodies are managed. The effectiveness of strategies for adapting to climate change depends on the social acceptability of options for adaptation, the institutional constraints on adaptation, and the place of adaptation in the wider landscape of economic development and social evolution.[8] Research needs to contribute to an understanding of all three.

Adaptation processes involve the interdependence of agents through their relationship with each other, with the institutions in which they are situated, and with the resource base on which they depend. The nature of these relationships has been central to human ecology and geography, microeconomics, psychology, anthropology and the political sciences. Each discipline has theorized relations of trust, the nature of exchange relations and the cultural significance of and institutional constraints on the use of the natural environment. Economics has tended to focus on situations in which the agents can be expected to "know" or to have learned the consequences of different actions so that their

observed choices reveal stable features of their underlying preferences. Economic theory is used to calculate how certain variations in the situation are predicted to affect behavior, but these calculations obviously do not reflect or usefully model the adaptive process by which subjects have themselves arrived at the decision rules they use.

Psychology has focused on "initial conditions" that determine the time path of a subject's behavior.[9] Research is required to find ways to measure and assess adaptive capacity, for example by conducting a further inquiry into the role, actual and potential, of adaptative elements in empirically oriented economic theory. Also, the political economy aspects of adaptation need to be considered in more detail, for example the role of vested interests such as homeowners in exposed areas, and the way different adaptation actors interact, for example in competition for water rights.

Incomplete markets shape the adaptation-related investments of firms including smallholder farmers. In rural areas of developing countries, financial market imperfections are pervasive, and there are broad regions in which almost every household manages farmland, effectively a firm. In these contexts, those facing constrained access to credit or insurance may choose to invest less, or differently, on their firm or farms than they would under perfect markets. Exposure to uninsured risks is another major constraint to technology adoption, including climate-smart technologies. Farms or firms that are exposed to risk invest more in unproductive assets to avoid the downside risk associated with exposure to flooding. This translates into lower income levels.

To respond to this, progress has been made with index-based insurance that could be well adapted to the conditions of smallholder farmers, with payouts triggered by a verifiable local rainfall index or a satellite-based small-area yield estimate. The use of index insurance has been shown to make a difference in inducing higher risk–higher yield investments in agriculture, but adoption has remained low. Research is required to identify ways of overcoming such practical barriers to adaptation. Insights from experimental psychology, which has traditionally focused on the process by which decision rules are replaced by others, may help to narrow the class of empirically interesting equilibria in certain economic models.

Many adaptation interventions, such as enhancing the resilience of infrastructure or providing common resources without clearly enforceable property rights like biodiversity, have traits of a public good and their benefits are expected to accrue over a longer time horizon.[10] Collective action is at the heart of many decisions regarding the management of natural resources. In agriculture, forestry, and other resource-dependent livelihoods, resources frequently exist under multiple property rights regimes. There are many different users, and there is limited information about the impacts of environmental change on sustainability.

Different social sciences have explored how societies choose to allocate scarce resources in the face of limited information and uncertain futures. Common to all theories of social interaction is the recognition that collective action requires networks and flows of information between individuals and groups to oil the wheels of decision-making. The nature of climate-related risk, the institutional context, the homogeneity of the decision-making group, and the distribution of the benefits of management and other factors are all important for collective action for adaptation. Greater insight can be gleaned on how collective action is central to adaptive capacity at various scales by case-specific research.

To generalize, one needs to learn from theoretical insights into institutions. In particular, there are the institutional prerequisites for the evolution and persistence of collective action and its relative importance compared to government intervention. To develop a conflict-sensitive climate adaptation strategy, for example, there is a need to better understand the climate security nexus and the ways in which this applies to the local context. Triangulated research methods involving local communities and climate security practitioners could result in an effective early-warning system that informs the development of adaptation solutions to address climate security risks.

Development economists are acutely aware of the importance of climate change for development.[11] They are concerned that unmitigated climate change will hit poor people particularly hard and may put development achievements at risk. But the climate risks that countries face are also determined to a considerable extent by the development decisions they take. The practical question that follows is:

How does climate-resilient development differ from conventional development? According to the IPCC, the risks associated with a given climate hazard are a function of the vulnerability and exposure of an economy to that hazard. Vulnerability and exposure can be reduced through appropriate adaptation. Of these three factors, economic development will generally lead to higher levels of adaptation, but vulnerability and exposure may either increase or decrease, depending on the development choices that are made.

The link between economic development and the level of adaptation is not obvious because development progress affects both the supply and demand for adaptation. On the supply side, the ability of economic agents to handle climate risks is a function of technical capacity, institutional factors and financial aspects (see discussion above). On the demand side, as income rises there is an increase in the demand for climate protection. The net effect of economic development, and a shift in location of economic activities from rural to urban, on vulnerability and exposure is ambiguous.[12] Further research is required to embed adaptation thinking into economic development plans. In macroeconomic terms, one way to model this is as the simultaneous accumulation of productive and adaptation capital.[13]

RESEARCH FOR INFORMING DECISION-MAKING ON ADAPTATION

Making adaptation decisions can be complex, requiring careful consideration of multiple factors and perspectives, and balancing different priorities over different timescales. Societies are said to only be at the start of a learning process that will continue for decades.[14] Decisions on adaptation are made by individuals, groups within society, organizations and governments on behalf of society. But all decisions privilege one set of interests over another and create winners and losers. Mainstreaming adaptation refers to the process whereby climate change concerns become an integral part of decision-making and influence the ways in which actors perceive the problem and consider climate change in their day-to-day activities.

At the macroeconomic level, successful adaptation policy would reduce tradeoffs across sectors and promote synergies; reduce under- and overreaction by departments, organizations, or ministries in response to climate change impacts; prevent inefficient investments of (scarce) resources; and promote coherence and consistency in implementing actions on the ground.

As mentioned before, long-term climate projections would facilitate policy design. But other challenges remain. We know a fair amount about the adaptation response of farmers, but much less about other sectors, such as the adaptation behavior of firms. We still know too little about the aggregate costs and benefits of adaptation and their distribution. Many adaptation interventions have traits of a public good and their benefits are expected to accrue over a longer time horizon. This renders their rate of return difficult to assess and quantify. In addition, adaptation lacks a commonly accepted metric for comparing and valuing its benefits, similar to the system of carbon credits received for investing in climate change mitigation.

Adaptation finance is meant to be provided over and above traditional development assistance. To quantify the incremental cost of adaptation, development projects would need to be designed under two scenarios: with and without climate change. While conceptually challenging, this is a promising line of inquiry. Of course, the two forms of funding are fungible, which means recipient countries will realign their spending decisions to achieve the adaptation–development mix they desire.

For decision-makers to be able to move from predict-to-act to risk-of-policy approaches, researchers need to assess the effectiveness of adaptation policies at the sector level, including the performance of adaptation measures under different climate scenarios, and then integrate these results in economy-wide models where they can also make linkages to the mitigation agenda. Such economy-wide models would also allow policymakers to assess impacts of adaptation strategies on poverty reduction and employment generation, which are important considerations from an equity point of view. The Comprehensive Africa Agriculture Development Program (CAADP) provides a good guide for the risk-of-policy approach.

At the local level, adaptation preferences have been found to be rather heterogeneous and conditioned by a host of social factors across the African continent. Case studies reveal that local

preferences consistently supported the need for both autonomous and planned adaptation; a mix of hard and soft measures; and awareness of the importance of pursuing both collective and individual adaptation measures.

In addition, the adaptation strategies perceived to be most effective were those that addressed underlying drivers of vulnerability, rather than those that focused on climate change alone. Further research is required on adaptive behavior at the local level, for example the farm household, so that simulations run on that level can inform and predict the workings of the overall economy. Insights in adaptive behavior could also inform policy measures designed to build adaptive capacity of the more vulnerable.

Decision-making for scaling or replication of adaptation actions needs to be informed by learnings from adaptation actions on the ground. Several projects have already introduced adaptation solutions, for example a climate-smart adaptation technique or providing weather index–based insurance to farmers, but an intervention bias, the pilot or experimental nature of such initiatives, and a lack of methodologically sound impact studies, makes it difficult to draw lessons from these.

Impact evaluation, which includes identifying impact pathways of adaptation actions, would shed light on the limits to adaptation and reduce the risk of maladaptation pathways.

Of course, a sound evaluation would require a baseline and ideally a control group and thus needs to be conceived of ex ante. In addition to conventional impact evaluation, any new adaptation project or program, such as those under the Africa Adaptation Acceleration Program (AAAP), would have to be accompanied by research for the duration of its life cycle. Accompanying research is crucial for enhancing the impact of adaptation interventions. For example, data collection and analysis during project implementation can shed light on barriers to "soft" measures to address these.

To summarize, to achieve sustained uptake of adaptation solutions at scale, research efforts need to produce and ensure dissemination of comprehensive and disaggregated information on climate risks, to identify context-relevant adaptation solutions with high potential for uptake, and to develop decision-making tools that enable scaling. What is more, these various elements need to speak to each other.

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