UNIVERSAL METRICS FOR CLIMATE ADAPTATION AND RESILIENCE

CONCEPT NOTE

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Abbreviations

A&R	Adaptation and resilience
AR5, AR6	Fifth and Sixth Assessment Reports of the IPCC
CO_2	Carbon dioxide
DALY	Disability-adjusted life year
ESG	Environmental, social and governance
FAO	Food and Agriculture Organisation
GIF	Global Innovation Fund
ha	hectare
IPCC	Intergovernmental Panel on Climate Change
kg	kilogram
M&E	Monitoring and evaluation
PPP	Purchasing power parity
PYI	Person-years of income-equivalent
RCT	Randomised Controlled Trial
Rs	Rupees
UNFCCC	United Nations Framework Convention on Climate Change

1.Introduction: Background, Purpose, and Audience

The 2021 United Nations Climate Change Conference, COP26, saw climate adaptation and resilience (A&R) in the limelight, acknowledged as a global goal of the highest priority. Developed countries reaffirmed their (so far unfulfilled) commitment to devote $100 billion annually to A&R in developing countries.

But while money is essential, it should be spent as effectively as possible. And here we run into a problem: what exactly is A&R and how will we – investors and stakeholders – know if we are achieving it? For climate mitigation, there is a straightforward metric: tons of CO_2 abated. In contrast, there is no standard yardstick for appraising the A&R ambition of an investment or measuring its actual success. This impedes efficient investment; complicates the United Nations Framework Convention on Climate Change (UNFCCC) task of a global stocktake of A&R progress; and inhibits our ability to learn what works, in what contexts, and why, in promoting A&R.

This paper outlines an approach to two related goals:

- **Incorporating A&R impacts into investment project[1] appraisals** (and into evaluations of completed projects): climate projects can provide a wide range of benefits, and many development projects contribute to A&R. The Global Innovation Fund (GIF), like some other investors, appraises project proposals based on a single, comprehensive measure of *all* the social benefits the project delivers. GIF has recently launched a sub-fund (the Innovating for Climate Resilience fund) focused on A&R. *How should GIF incorporate A&R benefits into its impact assessment methodology?*
- **To allow investors and the global community to track, with a common yardstick, contributions to A&R:** impact-oriented investors who make commitments to advancing A&R need a mechanism for tracking impact and holding themselves accountable. Commercial investors wish to be recognised, as part of an Environmental, Social, and Governance (ESG) framework, for A&R co-benefits

[1] Using the generic term ‘project’ to refer to any kind of investment: in a for-profit company, in an NGO or community-led initiative, or in a government program.

arising from their investments. The UNFCCC wants to assess progress toward adaptation, as part of its global stocktake. *How can these efforts be compared and aggregated?*

Audiences

This concept note has two audiences:

- GIF stakeholders and other investors pursuing detailed economic analysis of their investments (where the paper outlines the direction GIF will take in accounting for A&R benefits within its Practical Impact methodology).
- A wide range of investors and other actors with roles in A&R (where the paper builds on the framework GIF seeks to follow, and proposes a direction for tracking, comparing and aggregating contributions to A&R)

The argument in brief

I take the objectives of A&R activities to be to:

- Sustainably improve human well-being in the face of a variable and changing climate
- Maintain the functions and diversity of natural ecosystems as an intrinsic value, above and beyond their instrumental contribution to human health and livelihoods.

This concept note focuses on the first objective, **arguing that the ultimate test of how much a project contributes to A&R is how much it makes people better off, taking climate shocks and stresses into account.**

In this note A&R is measured not as a capacity, but as an impact measured in welfare terms. This impact can be expressed in a common currency, such as utility or dollar-equivalents. A common currency allows comparison of impact and cost-effectiveness across a very broad range of projects and climate threats. This approach is inspired by the invention of Disability-adjusted Life Years (DALYs), which has allowed policymakers to set priorities and compare cost-effectiveness across an immense range of illnesses, preventive and curative treatments, and populations.

The approach does not work for all possible A&R projects and is not well-suited to enabling activities, whose impacts are diffuse or hard to predict. While it can assess the *instrumental* value of ecosystem resilience (carbon storage by forests, or seafood harvests from reef-based ecosystems, for example), there is no easy way to compare the *intrinsic* value of different ecosystems in a common currency.

Plan of the paper

The next section is aimed at both audiences and lays out an understanding of A&R, and a typology of projects that can address them. The third section is oriented to the first audience and sets out an approach for incorporating A&R impacts into GIF's methodology for comprehensively assessing a project's benefits. The fourth section builds on the third and is aimed at the wider audience, here the challenges related to formulating a universal measure of resilience are described, and an approach, based on the poverty dynamics literature, is proposed.

2. A typology of climate adaptation and resilience efforts

What is ‘adaptation’ and how does it differ from ‘resilience’? Annexe 1 provides IPCC definitions for guidance. *Adaptation* involves adjusting to climate change, but many societies struggle to cope even with current-day droughts and floods. IPCC refers to this as an ‘adaptation gap’ and considers that closing this gap also constitutes adaptation. IPCC defines *resilience* as a general capacity that could contribute to adaptation (section 4 revisits resilience, drawing on the economics literature).

Although adaptation involves adjustment to ‘expected climate and its effect’, project planners don’t always know what to expect. On one hand, IPCC can confidently predict some changes, even at the local level. Sea levels are rising, glaciers are melting, and temperatures are trending upward and spiking more often (see Annexe 2, panel a).

However, deep uncertainty (see definition in Annexe 1) underlies some climate changes. In some cases, current climate models are unable to detect or predict even the direction of change (see annexe 2, panel c) This is because the ‘noise’ of year-to-year climate variability can be so great it is hard to discern the ‘signal’ of change, even if that is itself large.

Adaptation efforts also take place on different timelines, and with different degrees of observability. Projects that mitigate damage from chronic flooding may have impacts that can be measured within a few years. This falls comfortably within the typical span of project monitoring and evaluation (M&E). In contrast, M&E will probably not observe the full impact of a project that protects against once-in-20-year floods or droughts. And it could be decades before anyone can observe the success of current investments aimed at reducing the long-term vulnerability of cities to rising sea levels.

These considerations suggest the project typology shown in Table 1. This typology underpins the model-based approach described in the next section.

		Degree to which the project’s human impact can be:	
Challenge Type	**Example**	**Modelled?**	**Observed within 5 – 10 years?**
1. Current climate stress with well understood trends	Intensifying annual drought; intensifying chronic flooding	High	High
2. Disaster risk management: Extreme but infrequent climate events with well understood trends	Severe heat waves; cyclones	High	Low
3. Current climate variability, with unclear trends	Drought in some areas	Medium	Medium
4.Planning now for predictable long-term ecosystem changes in water availability, cropping suitability, etc.	Coastal salinization and inundation; shifts in agroecological suitability for crops; glacial loss	Low to High	Low
5.Planning now for unpredictable long-term changes	Water basin planning where long-term direction and pattern of precipitation is unknown	Low	Low
6. Capacity-building for adaptation planning	Training, institution-building, strengthening of hydromet data systems	Not applicable	Not applicable

Table 1 Typology of climate challenges and associated projects

3. Building A&R into project impact appraisal

Starting point: Practical Impact

The impact assessment approach proposed here builds on GIF's Practical Impact framework. GIF seeks to maximise its social benefits for people living on less than $5 per day. GIF does this by investing, across all sectors, in innovations with the potential for massive long-term scale-up and impact. Practical Impact was designed to help GIF choose the most impactful candidate investments, and to track the evolving impact of its portfolio.

The Practical Impact framework is shown in Figure 1. It starts with a projection of the number of people who will benefit in 10 years if the innovation successfully scales. This is then adjusted by the depth of impact (the relative change in well-being for a typical beneficiary). Finally, this impact is adjusted by an assessment of the probability that the innovation actually succeeds in scaling to the hoped-for level. Because GIF tries to build evidence generation into its investments, the estimated impact is updated over time as risks are resolved and impact is better measured (see Box 1 for information on how Practical Impact is measured).

Figure 1 GIF's Practical Impact framework

The preferred unit of measurement for Practical Impact is the person-year of income-equivalent (PYI). This is, essentially, a utility measure. Depth of impact is utility (in income-equivalent) with the project relative to utility without. For instance, a project that boosted a person's income by 20 per cent for one year would have a depth of 0.2 and would generate 0.2 PYI. If the project boosted 1,000 people's income by 20 per cent for three years, it would generate 1,000 x 0.2 x 3 = 600 PYI.

As is standard in health economics and benefit-cost analysis, there are conversion factors for improvements in health and education, or reductions in mortality. For instance, one year of extra education for one person is reckoned as 1 PYI. A life saved is reckoned as 50 PYI. These parameters explicitly embody value judgments. However, value judgments are made implicitly whenever an investor chooses, say, a livelihood project over a health project. GIF believes that transparent statement of values leads to consistency of analysis.

Alternatively, the framework can be applied using standard benefit-cost analysis, where net benefits are measured in dollars. For GIF, which is poverty-focused, the advantage of PYI is that it attaches a higher value to boosting someone's income from $1 per day to $2 per day (depth = 1.0) than it does to boosting income from $10 per day to $11 per day (depth = 0.1) It also accords the same value to mortality reductions in all countries, in contrast to the value of a statistical life approach, which places a higher dollar value on mortality reductions in countries with higher per capita incomes.

Box 1 Units of measurement in Practical Impact

Practical Impact has two features that make it attractive as a starting point for adaptation metrics. First, it allows structured comparison across many different types of projects. This is relevant for priority-setting in adaptation. People face many different climate threats, and there are often multiple ways of addressing a particular threat. How should investors or governments construct the most beneficial portfolios of action?

Second, Practical Impact grapples with the fundamental uncertainties about investment in innovation. Innovations are inherently risky, so probability of success must factor in. Also, it takes a long time for innovations to achieve their full potential reach. As a result, Practical Impact must explicitly model the long-term diffusion and adoption of an innovation to gauge its worth. Long-term, probabilistic modelling is directly relevant to climate challenges 2 (disaster risk management) and 4 (long-term fundamental change) of Table 1.

Extension to adaptation investments

How, then, to extend Practical Impact to adaptation investments? The essence of an A&R project, as opposed to an 'ordinary' development project, is that it identifies and addresses climate challenges. Often, an explicit climate model will be a key element of project design. That is because the success of disaster risk management projects, and long-term adaptation projects, will not be fully observed during project implementation (as noted above). Project designers need to be able to convince investors and stakeholders that the project will in fact promote resilience to the once-in-20-year flood, or adaptation to a decades-long process of sea level rise and salinisation. The climate model could be very simple: for instance, a project involving rainfall index insurance could be based on the frequency that rainfall falls below a certain threshold necessary for crop survival. Or it could be very complex, feeding a downscaled global circulation model of climate into a hydrological model of rainfall, soil moisture, and crop response. Whatever the level of complexity, the core idea is that outcomes vary according to the realisations of climate or weather, and we can say something about the likelihood of different realisations and trace their intermediate outcomes and ultimate impacts.

Construction of an A&R assessment begins with a theory of change like that of Figure 2. It articulates the climate shocks and stresses to which households are exposed; their baseline levels of vulnerability and coping capacity; how the project strengthens them; and with what result. Referring back to the typology of Table 1, a quantitative framework like this should be usually possible for challenge types 1 and 2, and often for types 3 and 4. For instance, there is burgeoning experience with the construction of index-based agricultural insurance, where premiums and pay outs are determined based on a risk analysis. Service companies such as Global Parametrics, and Cloud to Street, use remote sensing and/or modelling to quantify hazard risks. A sophisticated example of climate-economic modelling is the Global Resilience Index Initiative.[2] This assesses the impact of resilience-building for infrastructure on the reduction in the macroeconomic costs of disasters. It includes the indirect economy-wide costs of disruption, in addition to the direct costs of damage to transport and power networks.

[2] https://www.cgfi.ac.uk/global-resilience-index-initiative/

Figure 2 Theory of change for an A&R project

A stylised example of a resilience analysis is shown in Box 2. It is based on two studies (Dar et al[3] and Emerick et al[4]) of the impact of introducing a flood-resistant rice variety to semi-subsistence farmers in a flood-prone region of Odisha in India. The seed was shown in agronomic trials to boost yield by two tons/ha in flood conditions, without a yield penalty in normal years. Researchers tested it in the field, as part of an RCT. As expected, the seed performed better in the study's first year, which was a flood year. But adoption of this innovation also catalysed far-reaching adaptive responses by the farmers. As they now faced a lower risk of losing their crop, they were willing to invest more in fertiliser and in labour-intensive planting. Their perceived resilience increased, so they were able to reduce their storage of rice as a hedge against the possibility of a failed crop next year. This holistic adaptive response resulted in a boost to farm incomes in the following normal year, compared to the control group.

Box 2 uses this data from the study to present a stylised analysis of resilience impact assessment (because the analysis is at the plot level rather than the farm level, this example is purely illustrative and should not be cited as an assessment of the actual innovation). A

[3] Manzoor H. Dar et al., 'Flood-Tolerant Rice Reduces Yield Variability and Raises Expected Yield, Differentially Benefitting Socially Disadvantaged Groups', *Scientific Reports* 3, no. 1 (22 November 2013): 3315, https://doi.org/10.1038/srep03315.
[4] Kyle Emerick et al., 'Technological Innovations, Downside Risk, and the Modernization of Agriculture', *American Economic Review* 106, no. 6 (1 June 2016): 1537–61, https://doi.org/10.1257/aer.20150474.

key feature here is that the researchers were able to use publicly available satellite data over 11 years to assess the probability that a farm plot would be flooded. The Box uses this probability to estimate the expected impact of introducing the improved seed on plot-level income. It combines *measurement* of depth of impact (contingent on whether there is flooding) with a *projection* of the likelihood of flooding. This, I argue, is essential to deal with Category 1 to 3 challenges, where the extreme climate event might not occur before an evaluation is undertaken.

The analysis could be further refined, in several ways. First, it could project (and then track) diffusion of the innovation at the level of the farmer. At the time of the study, farmers introduced to the new seed were cultivating, on average, 1.5 of their 3.5 plots. One would expect that over time, as confidence in the new seeds grew, the farmers would devote a larger proportion of their farms to the new seed. This would boost the impact/ha shown in Box 2, which is an average over all plots cultivated by the 'treated' farmers. It is also possible to model external diffusion. Dar et al. note that this seed could be beneficial for up to 14 million ha of riceland in India alone.

Second, a more granular approach would look in detail at how the innovation protects farmers from vulnerability. Dar et al. found that poor, marginalised farmers disproportionately own low-lying, flood-prone plots. Furthermore, yields decline precipitously as flood duration increases. The improved seed boosts yield by up to 66 per cent, for a 13-day flood. Taking the lens of Practical Impact, we can view that as roughly indicating a 66 per cent increase in income relative to the alternative – a huge boost. This measure provides a better indicator of resilience since it captures the depth of the shortfall that the innovation has averted.

The timeframe for evaluation will depend on the nature of the project. To date, most Practical Impact assessments use a 10-year horizon as the limit of what is predictable. This is appropriate for many Type 1 -3 projects. An example of a project of this type would be a climate-smart agriculture initiative that introduces farming practices to meet the current adaptation gap, while also setting up systems that adjust those practices to meet evolving changes in climate. However, some Type 2 and 4 projects may set up institutions or infrastructure with enduring benefits. For instance, a nature-based solution to buffer floods may foreseeably provide benefits for decades, or even centuries if it shifts urban settlements away from vulnerable areas. (This raises issues of whether and how to apply declining discount rates for long term investments, not further discussed here).

The approach outlined here doesn't apply to challenge Type 5, where there is no ability to assign probabilities, even roughly, to different climate scenarios. There is literature on robust decision making under deep uncertainty (see Hallegatte et al 2021[5], who outline a procedure for project assessment under uncertainty as well as approaches to Type 2 projects). Capacity-building (Type 6) is also difficult to fit into this framework unless there is a clear link to addressing Challenges 1-4.

[5] Stephane Hallegatte et al., 'Integrating Climate Change and Natural Disasters in the Economic Analysis of Projects', 2021, 88, https://doi.org/10.1596/35751.

Emerick et al 2016 and Dar et al 2013 used an RCT to measure the impact of introducing Swarna-Sub1, a flood-tolerant rice variety, to farmers in two flood-prone regions of Odisha in India. Farmers in the experimental treatment group received a five kg minikit of Swarna-Sub1 seeds. Emerick et al 2016 compared plot-level yields of treated versus untreated farmers. (Note that not all plots in the treatment group were planted to Swarna-Sub1. Farmers work multiple plots so treatment refers to the farmer, not the plot).

Table A is a stylised example showing how knowledge of climate risks (the probability of an extreme event such as flooding) and climate-dependent outcomes (yield under flooded versus normal conditions) can be used to assess an innovation's impact. In the table, Δ is the difference between treatment and control. Treatment farmers fared better even in non-flood years because they were more confident that investments in fertiliser, and in more careful planting, would not be wasted. Because the analysis is carried out at plot level rather than farm level, it should not be taken as assessment of the actual programme.

Table A Stylised example: impact measured in Rupees

Climate realization	Probability	**Δyield, kg/ha**	**Δrevenue, Rs/ha**	**Δ cost, Rs/ha**	**Δ profit, Rs/ha**	**Prob*Δprofit, Rs**
flood	19%	315	3305	1103	2202	418
Non-flood	81%	283	2969	1103	1866	1511
AVERAGE						1929

Note: based on data from Emerick et al 2016

The expected impact of being exposed to Swarna-Sub1, averaged over flood and non-flood conditions, is an increment of Rs 1929/ha. This is an underestimate of the long-term impact that would result if farmers planted all their rice plots to Swarna-Sub1. It also doesn't account for dynamics. Farmers with the improved seed enjoy greater surpluses and are seen to expand the area cultivated. Farmers with drought-tolerant seed may need to draw down their reserves and could spiral into poverty.

An alternate measure (Table B) would use the Practical Impact metric (Box 1). This looks at proportional increase in income due to use of Swarna-Sub1 and recognises that incomes could fall disastrously for farmers using flood-sensitive varieties. This example is purely illustrative, with hypothetical data. In mild floods, the innovation boosts income by 40 per cent, relative to what would have been experienced by a farmer without flood-tolerant seeds. That increment goes to 60 per cent in a severe flood. This lens accords greater weight to impact during the relatively unlikely, but highly damaging, flood events.

Table B Stylised example: impact measured in PYI

Climate realization	**Probability**	Increment in annual household income due to the innovation (relative to counterfactual)	Probability-weighted impact, PYI
Mild flood	10%	40%	.04
Severe flood	10%	60%	.06
Non-flood	80%	10%	.08
AVERAGE	*Note: based on hypothetical data*		.18

Box 2 Stylised impact analysis: flood-resistant seeds

4. General metrics for resilience and adaptation

Motivation and activity

Many groups are now working on developing metrics for A&R with a particular focus on the needs of investors. These include the Adaptation and Resilience Investors Collaborative; Climateshot; the Global Resilience Partnership; the International Platform for Adaptation Metrics; and the Race to Resilience.

Motivations for this work include:

- Reporting on climate finance – developed countries have committed to providing $100 billion per year for adaptation by developing countries Climate markers provide a way of tallying progress toward this goal.
- Impact-oriented investors may have made commitments to advancing A&R and need a mechanism for tracking impact and holding themselves accountable.
- Commercial investors wish to be recognised, as part of an ESG framework, for A&R co-benefits arising from their investments.
- Defining metrics for measuring progress on mitigation, adaptation, finance and implementation against the UNFCCC's Paris Agreement goals – the associated global stocktake will take place between November 2021-November 2023, however, metrics are yet to be defined.
- Developing rigorous evidence on the effectiveness of A&R projects – a new systematic review of 48,000 papers on adaptation found that only 5 per cent dealt with implementation, and only 30 papers presented 'primary evidence of [climate] risk reduction.'[6] Even with a larger body of evidence, lack of a common metric is a major impediment to learning in a way that supports synthesis of finding on what works, for what kind of climate challenges, under what conditions.

Approaches and issues

Here is a brief (and not comprehensive) summary of existing approaches to A&R metrics, with their advantages and disadvantages.

Finance-focused

Currently the most widely used metric for A&R is the Organisation for Economic Co-operation & Development's Development Assistance Committee Rio Marker and related 'tagging' schemes such as the Multilateral Development Banks' Joint Methodology. Investments are marked as adaptation if project documentation explicitly indicates a climate change adaptation objective and explains the specific measures used to achieve that objective.

This approach supports the goal of ensuring adequate finance for climate adaptation and has a history of implementation to draw on. However, measurement of inputs (finance) provides no insight into effectiveness, let alone cost-effectiveness.

[6] Berrang-Ford, L., Siders, A.R., Lesnikowski, A. et al. A systematic global stocktake of evidence on human adaptation to climate change. Nat. Clim. Chang. 11, 989–1000 (2021) https://www.nature.com/articles/s41558-021-01170-y

Characteristics of resilience; resilience as a capacity

Several approaches look for the characteristics of projects that support resilience or adaptation. They treat resilience as a capacity. For instance, the Food and Agriculture Organisation of the United Nations Resilience Index Measurement and Analysis uses factor analysis to identify latent pillars of resilience at the household level, including assets and access to services. The TANGO framework[7] also used multi-dimensional measures of household resilience. The World Bank's Resilience Booster[8] identifies nine systems-level aspects of resilience, such as redundancy, connectedness, and robustness. The 3As Framework for resilience[9] identifies three aspects of resilience: adaptive capacity, anticipatory capacity, and absorptive capacity. The official UK guidance on measuring contributions to resilience is based on the 3As framework[10] – it suggests devising metrics for at least two of the three capacities, and setting thresholds for those metrics to represent the achievement of resilience.

These approaches focus attention on project design, highlighting elements that are arguably important to resilience or adaptation. These elements can be related to outcomes or impacts, within the framework of Figure 2. But it is difficult to aggregate or compare the elements themselves across projects or locations.

Resilience as an outcome

When the focus is on specific climate hazards or interventions, resilience measures naturally focus on outcomes: reductions in the number of days when roads are washed out, reductions in heat-related crop losses, etc. These can be essential elements in understanding the value of specific interventions. However, individual outcome-related metrics don't add up to a comprehensive picture of how individuals or communities have progressed toward resilience or adaptation. For instance, a farmer faces a wide range of climate-related threats: heat, drought, floods, pests, and storms. While it might be important to know whether a new seed variety can protect farm incomes against heat waves, there may be alternate ways to address that specific threat (with insurance, for example) and other threats may loom larger. What's needed is a holistic measure of resilience to all these threats.

Resilience as people reached or benefited

The Race to Resilience framework[11] sets out five high-level metrics: people, companies, countries, cities, and hectares of natural systems 'with increased resilience.' These measures have the advantages of universality, aggregability, and simplicity, and lend themselves to the global goals addressed. However, the framework explicitly excludes consideration of depth of impact. It allows double counting in the case where an individual is made resilient against multiple hazards by multiple interventions.

In sum, none of these approaches offer a metric that satisfies all three of: comparison across interventions, aggregation across people, and consideration of the degree of resilience (or adaptation) conferred.

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7 https://www.tangointernational.com/resilience-research-archive.html

8 https://resiliencetool.worldbank.org/#/home

9 Bahadur, Aditya and others. The 3As: Tracking Resilience across BRACED. BRACED Knowledge Manager Working Paper. https://cdn.odi.org/media/documents/9812.pdf

10 Climate Change Compass. Number of people whose resilience has been improved as a result of ICF. KPI 4 Methodology Note. September 2019.https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835527/KPI-4-number-people-resilience-improved1.pdf

11 https://racetozero.unfccc.int/wp-content/uploads/2021/11/202111_R2R_Metrics_framework.pdf

A resilience approach based on poverty dynamics

Barrett and Constas (2014)[12] define development resilience as:

“the capacity over time of a person, household or other aggregate unit to avoid poverty in the face of various stressors and in the wake of myriad shocks. If and only if that capacity is and remains high over time, then the unit is resilient”.

They then link the idea of resilience to the literature on poverty traps. In that literature, a resilient household is one that has enough assets (broadly construed) to be non-poor, on an upward trajectory, and able to recover from a small negative shock. But pushed below a minimum resilience threshold of assets by a big enough shock – a drought, a flood, an illness – the household might spiral into destitution, or even death. This leads to a definition of resilience as a *status* – above the threshold asset level, or not.

Figure 3 reproduces Barrett and Constas’ stylised illustration of resilience as evasion of poverty traps. Tomorrow’s expected well-being W_{t+s} is a function of today’s well-being W_t. as shown by the blue line (there is random variation above and below the blue line, not shown). People with well-being above threshold T2 are non-poor and will tend to get better off over time, ending up in the green upper right, where the blue line cuts across the dotted line. They will probably be able to recover from shocks that leave them in the green, non-poor zone. We consider them to be resilient. Those who start in the yellow zone will tend to end up at a lower equilibrium, in chronic poverty. Interventions that push above T2 make them non-poor and resilient. Shocks that push them below T1 send them spiralling toward destitution and risk of death.

Two papers operationalise this idea and apply it empirically[13]. They take assets (specifically livestock) as a determinant of resilience (assets substitute for W in the diagram above). They designate a threshold level of assets necessary for resilience. A household’s resilience level is the predicted probability that the household is above that threshold next year, given its assets and other characteristics this year. The papers use short-panel data to estimate year-to-year poverty dynamics.

The methods used by the two papers require some adaptation for present purposes. First, the econometrics is rather complex. Second, they rely on poverty dynamics during a short period of observation, and don’t capture rare but severe shocks (as in Box 1). The simpler alternative proposed here uses a climate model to forecast a household’s resilience status, based on a measure of its vulnerability, the hazard it faces, and the efficacy of the project intervention. However, it eschews modelling of poverty dynamics over time, as the cost of simplicity.

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[12] Barrett, C.B. and Constas, M.A. 2014. Toward a theory of resilience for international development applications. *PNAS* 111 (40) 14625-14630. https://doi.org/10.1073/pnas.1320880111

[13] Cissé, J. D., & Barrett, C. B. (2018). Estimating development resilience: A conditional moments-based approach. *Journal of Development Economics*, *135*, 272-284 https://doi.org/10.1016/j.jdeveco.2018.04.002
and Phadera, L., Michelson, H., Winter-Nelson, A., & Goldsmith, P. (2019). Do asset transfers build household resilience?. *Journal of Development Economics*, *138*, 205-227. https://doi.org/10.1016/j.jdeveco.2019.01.003

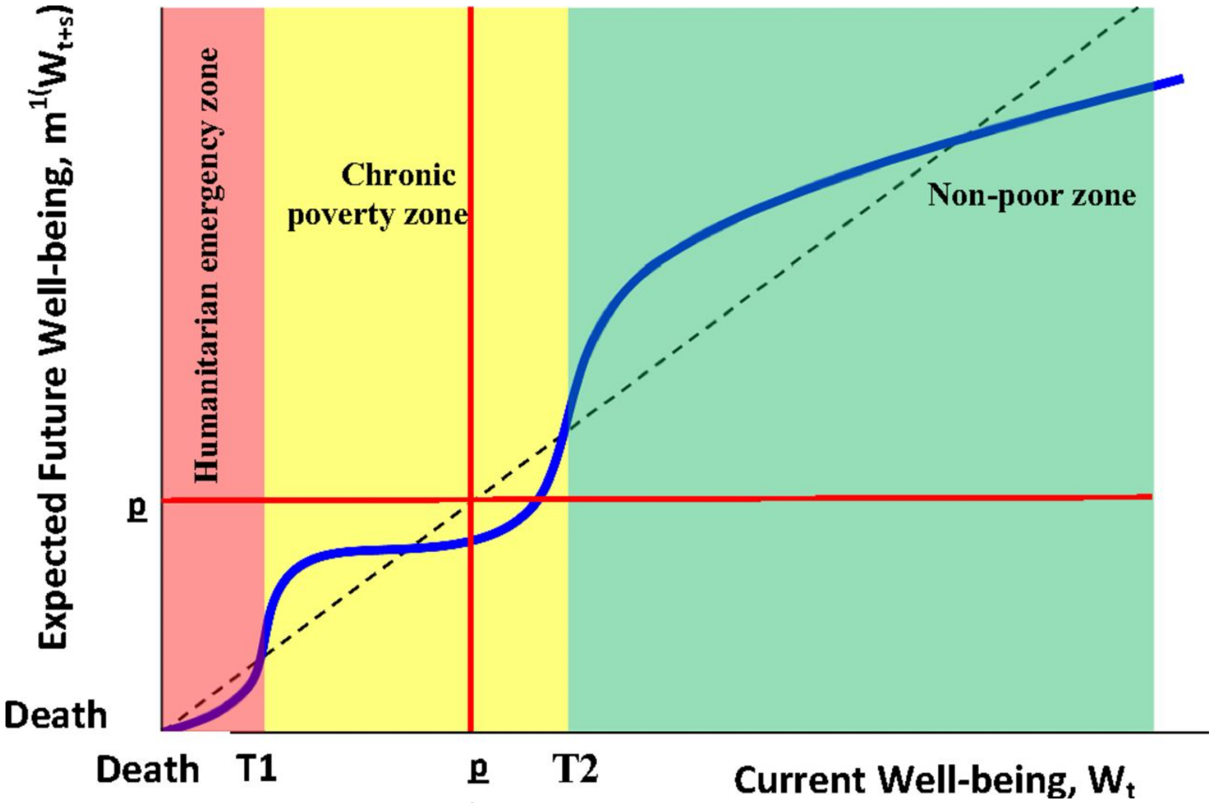

Figure 3 Poverty dynamics and resilience. Source: Barrett, C.B. and Constas, M.A. 2014. Toward a theory of resilience for international development applications. PNAS 111 (40) 14625-14630

Operationalisation

The proposal here is to use this framework to build a universal metric for resilience that is based on the number of people made resilient, but with a more specific and sensitive definition of what that means (this contrasts with the simpler but less sensitive definition used by the Race to Resilience). The theory of change is the same as Figure 2, but the goal is to count the number of people made resilient (lower left of diagram), in the sense of Barrett and Constas. It takes dimensions of *capacity* as explanatory variables, incorporates some representation of climate threats and how they are addressed, uses *outcomes* as intermediate variables, and focuses on resilience *status* for A&R reporting.

Figure 4 Operationalising a resilience measure

Climate realisation	Probability	Δ number of Resilient people
Drought	P_d	N_d
Normal	P_n	Nn
Flood	P_f	Nf
Expected impact	$P_dN_d+P_nN_n+P_fN_f$	

The format would be the same as in section three, but now the dependent variable is the expected number of people made resilient. The climate framework could incorporate multiple threats. (See Figure 4)

Potential indicators of resilience

Simplicity is the key. For ease of application and widest generality, we seek a widely-used, easily measured indicator that captures the idea of an asset bundle that supports the capacity to persist, adapt, and transform in the face of change. The idea is that falling below some threshold of the indicator – due to a climate or other shock – makes it hard to recover to an acceptable standard of well-being, or to continue to adapt and transform. Obviously any simple indicator and threshold will represent a stylised and imperfect representation of resilience. But a simple, 'good-enough' indicator that can be widely used is preferable to a nuanced one that is difficult or impossible to implement in most circumstances.

There are two ways to set a threshold for the asset bundle that constitutes resilience. These correspond to the thresholds T1 and T2 in Figure 3.

The lower threshold is a bundle that provides resilience against falling from poverty into destitution. Candidate resilience measures might include:

- *Nutritional status* – there are a variety of standardised nutritional status measures. Arguably, good nutritional status is a good proxy for resilience, while severe malnourishment is demonstrably associated with a lack of resilience. Resilience for a population could be defined as the proportion of children that are not suffering from moderate or severe malnourishment. Unlike many indicators that are only available at the household level, nutrition is measured at the individual level, allowing assessment of resilience by gender. Alternatively, it could be measured using a food security indicator.
- *International poverty line* – the international poverty line of $1.90 PPP is supposed to represent a minimum subsistence bundle. It is a widely used indicator, but its use here would differ from a standard headcount of poverty because the model looks specifically at how climate stresses and shocks affect people's standing relative to the line.

A higher resilience threshold, corresponding to T2, would be based on an asset bundle that provides resilience against falling into poverty. This could be based on:

- *Indexes of asset bundles* such as financial savings and livestock – indexes like these have been used, for example in projects that use the BRACED framework[14].
- *Multidimensional Poverty Index (MPI)* – the widely used MPI consists of 10 indicators of deprivation at the household level[15]. These include health, education, assets and access to electricity, water, and sanitation. A household that is deprived in a third of these measures is classed as 'MPI poor'. It might be possible to specify an alternative index, drawing on the base set of indicators, that represents a greater degree of resilience.

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[14] Aditya V Bahadur et al., 'The 3As: Tracking Resilience across BRACED', BRACED Knowledge Manager Working Paper, n.d., https://cdn.odi.org/media/documents/9812.pdf.

[15] Alkire, S., Kanagaratnam, U. and Suppa, N., 2021. The global multidimensional poverty index (MPI) 2021. https://ophi.org.uk/mpi-methodological-note-51/

- *National Poverty line* – finally, it would be possible simply to use a locally informed poverty line that captures national perceptions of a bundle that ensures a resilient, non-poor standard of living.

These simple resilience proxies don't capture important contextual sources of resilience, such as individual agency, social capital, institutions, and infrastructure. These could be incorporated in assessing the susceptibility of individuals to climate shocks.

Conclusion

Ultimately the principal goal of A&R is to enable the maintenance and improvement of human welfare over time, including the reduction of poverty. This note advocates A&R metrics focused on welfare impact, as measured by a single indicator such as dollar-equivalent or GIF's PYI. Such metrics offer an opportunity for comparison, aggregation, and priority setting among the immense range of climate adaptation needs, approaches, and locations. They encourage investors and stakeholders to ask not just: *is this the best way to achieve a specific outcome* (such as lower frequency of urban flooding)? but also: *is this the best of all possible ways to make a target population resilient or adapted?* They complement, rather than substitute, for measures of resilience as a capacity, or as contributions to outputs or outcomes.

The approach builds a bridge between A&R metrics and poverty metrics. Poverty reduction and climate adaptation are deeply intertwined. Poverty reduction will not be possible without adaptation and an overarching goal of adaptation is to prevent climate shocks from propelling people into poverty. The method here differs from traditional poverty analyses by building explicit climate representations into the analysis.

The approach is more complex to adopt than simpler metrics such as counts of people made more resilient. And there are some project types for which it is not easily applicable, such as enabling activities, and those focused on the intrinsic values of ecosystems. However, it offers two important immediate uses and advantages. First, it encourages stakeholders, project designers and funders to attend carefully to climate risks and benefits, including those that will not be observed during the immediate course of implementation but are crucial to long term adaptation. Second, it provides a means by which researchers and evaluators can begin to build up case studies of the impact of diverse sets of A&R interventions, allowing assessment of different approaches using a common yardstick. This can contribute to learnings that will inform a wider set of A&R efforts.

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Annexe 1: Relevant definitions from IPCC

Adaptation In *human systems*, the process of adjustment to actual or expected *climate* and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.

Adaptation deficit The gap between the current state of a system and a state that minimizes adverse impacts from existing climate conditions and variability. *Source: AR5 synthesis report, via IPCC glossary online.*

Deep uncertainty A situation of deep uncertainty exists when experts or stakeholders do not know or cannot agree on: (1) appropriate conceptual models that describe relationships among key driving forces in a system; (2) the probability distributions used to represent uncertainty about key variables and parameters; and/or (3) how to weigh and value desirable alternative outcomes.

Hazard The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

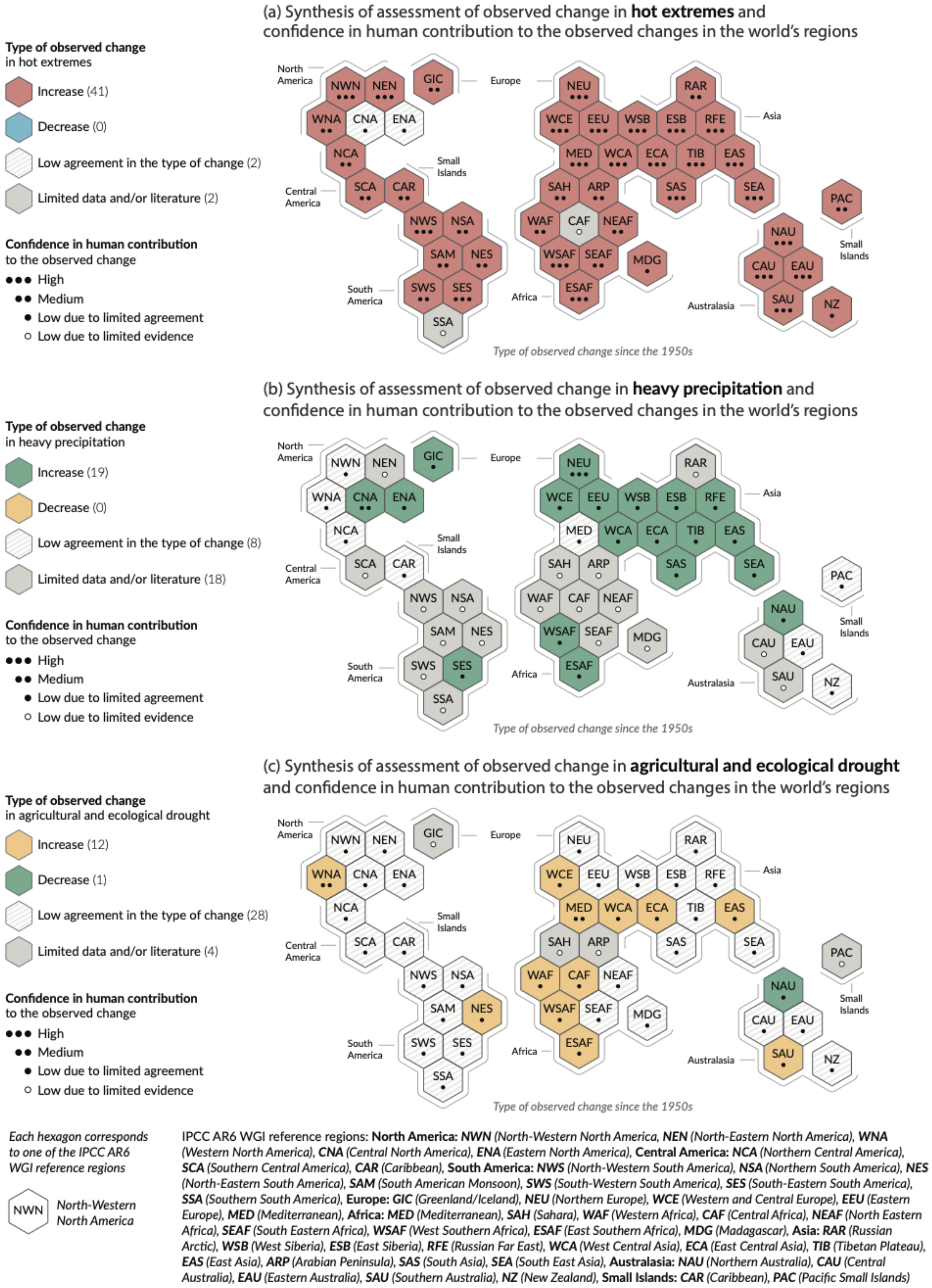
Resilience The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation.

Vulnerability The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Source: IPCC AR6 Working Group I Report, Annexe VII, except where noted.

Annexe 2: State of knowledge on climate change trends

Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes



Source: IPCC, 2021: Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson- Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.