PROJECTED CLIMATE ADAPTATION BENEFITS OF ONE CGIAR

Developed by

Julian Ramirez-Villegas (Alliance); Todd Rosenstock (CIFOR/ICRAF); Peter Steward (CIFOR/ICRAF); Philip Thornton (ILRI); Ana Maria Loboguerrero (Alliance); Andy Jarvis (Alliance)

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Key messages

- By 2030, CGIAR's work on climate adaptation is projected to benefit 234 million rural people in 59 million rural households in regions facing significant climate hazards.
- Some 66% of the projected individual beneficiaries are in SA (34%) and SEA (32%). India (26%) and China (24%) alone account for about 50% of beneficiaries globally. Approximately 15% are in SSA, equally divided between ESA and WCA; the remaining beneficiaries are in LAC (7%) and CWANA (11%).
- Adoption of climate-smart agricultural practices, climate-adapted varieties, and climate-related advisory services will increase productivity by an average of 24 % and, in at least 62% of cases, will also reduce interannual yield variability. Despite these significant potential upside gains, changing farming practices also carries production risk.
- Scaling up both improved varieties and improved agronomy could more than double economic benefits as compared to improved varities alone; this suggests that integrative programs that bundle several innovations have the potential to amplify impact.

Overview of the approach

In the present analysis, we first create a projection of the number of beneficiaries (rural individuals and households) in climate hazard areas using geospatial datasets on climate hazards and rural population. We assume an adoption rate of 2% for climate-smart agriculture (CSA) practices and climate information services (CIS) annually. Second, we compute average mean yield and yield stability benefits of CSA adoption using Evidence for Resilient Agriculture (ERA)[1].

Projected beneficiaries by 2030

We develop projections for two indicators on a country, regional, and global basis:

- The total number of rural individuals benefiting from adaptation
- The total number of rural households benefiting from adaptation

For each country and region, we use estimates of total rural population derived from WorldPop.org[2]. The number of households was estimated by dividing country-level rural individual populations by the average household size as reported by the Population Reference Bureau (PRB)[3]. Countries without PRB data were assigned the regional average. To ensure that our analyses are relevant to adaptation, we first define an extrapolation domain for CSA and CIS that encompasses all rural areas in CGIAR regions that are exposed to climate hazards. Climate hazards are defined following Jarvis et al. (2021) (Figure 1).

Next, we define an annual adoption rate. We assume that, by the end of each year, the percentage of rural people adopting CSA and CIS is 2% of the total population of non-adopters. We do not account for interannual variation in adoption nor any geographical differences in adoption rates that could arise from spatial variation in adoption constraints. Rates of agricultural technology adoption at scale has rarely been reported to exceed 2% per year (e.g., Thornton and Herrero, 2010). Nevertheless, it remains possible for adoption rates of certain technologies to exceed 2% annually. For example, large integrative programs like MasAgro[4] in Mexico show sustained adoption rates

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[1] ERA v2.0, http://era.ccafs.cgiar.org

[2] https://www.worldpop.org

[3] https://www.prb.org/international/indicator/hh-size-av/map/country/

[4] https://masagro.mx/es/

greater than 2% and an associated doubling of yield gains. Finally, we computed the number of beneficiaries that would adopt CSA and CIS within hazard-exposed areas for each country for the period 2022–2030 by multiplying the total population of non-adopters within hazard areas times the adoption rate (2%). We discount any beneficiaries in year *i* from subsequent years. The result is the total number of rural individuals and households projected to benefit from CSA and CIS work conducted by CGIAR from 2022 to 2030 (Figure 2).

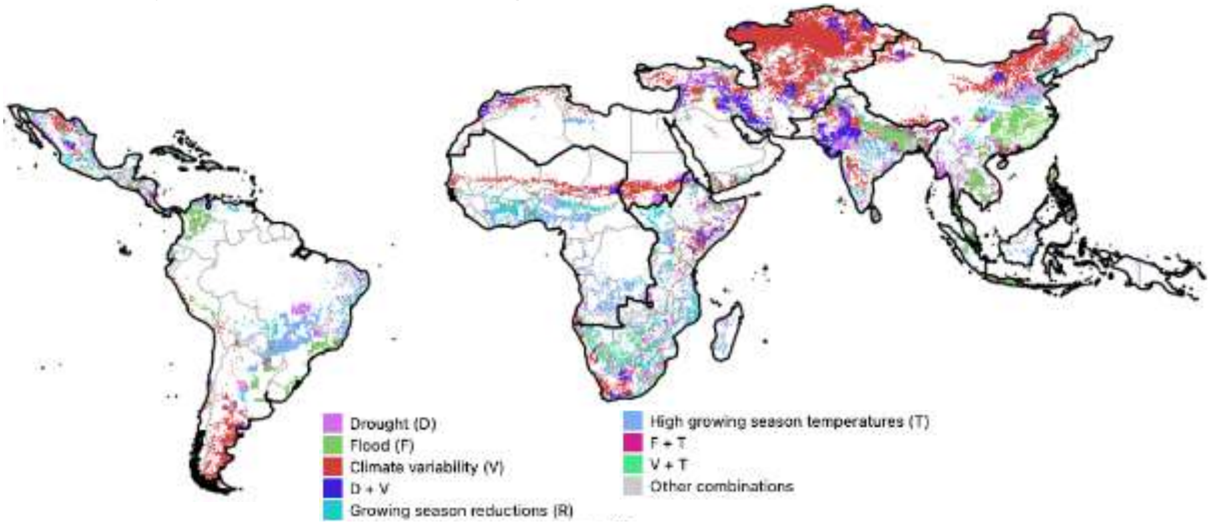

Figure 1 | Spatial distribution of climate hazards within One CGIAR regions.

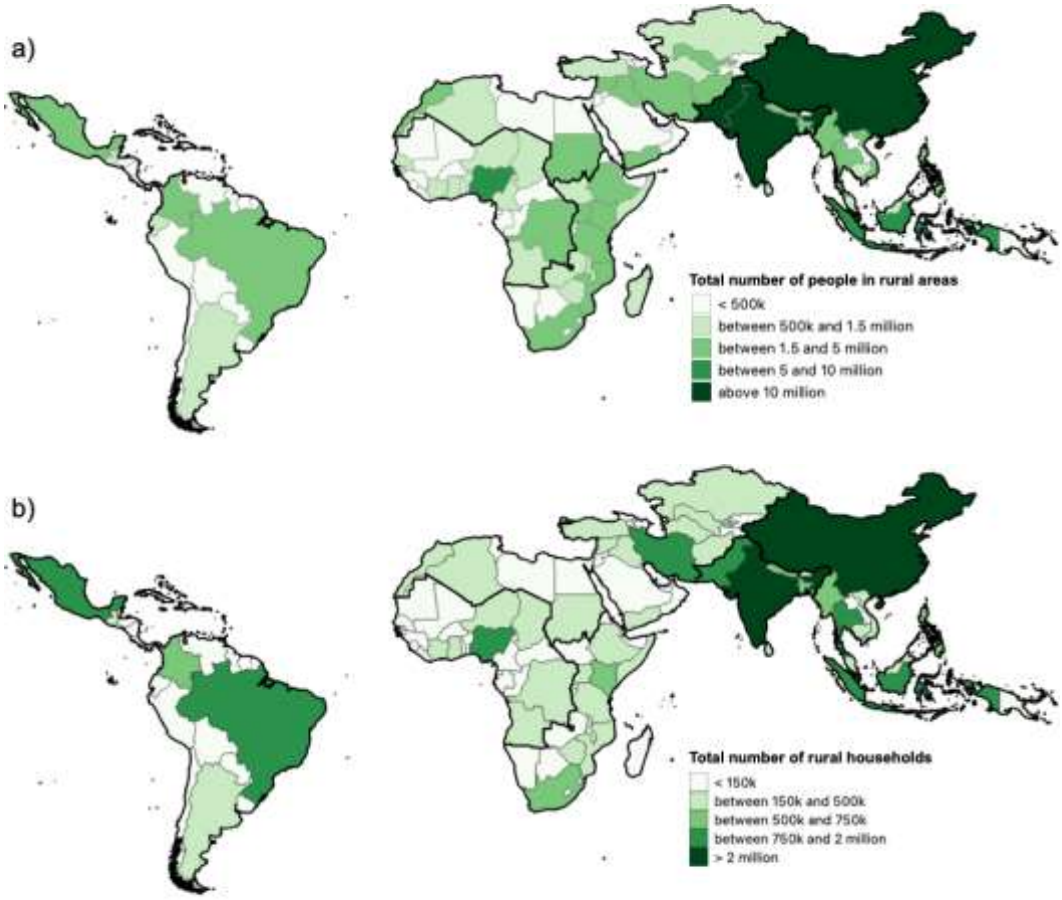

Figure 2 | Total number of rural individuals (a) and rural households (b) at the national level that are projected to benefit from work conducted by CGIAR on CSA and CIS 2022-2030.

Projected benefitting individuals and households of CSA and CIS work were aggregated by region (Figure 3). The largest numbers of beneficiaries are in SA and SEA. Within these respective regions, India (25%) and China (24%) contribute approximately 50% of the global total number beneficiaries. Table 1 shows projected total population and projected individual and household beneficiares by year (non-cumulative values) at the regional and global scales.

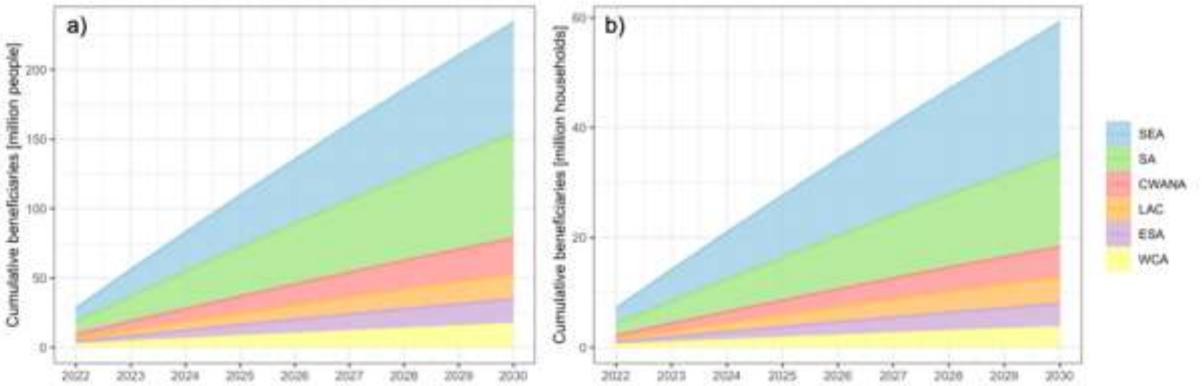

Figure 3 | Projected beneficiaries of CGIAR work in CSA and CIS by region, 2022–2030.

Table 1 | Annual number of individuals and households benefiting from CGIAR work in CSA and CIS 2022–2030, aggregated by region

Rural population (million people)

Region	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total adopters	Total population
CWANA	3.09	3.02	2.96	2.90	2.85	2.79	2.73	2.68	2.63	25.7	154.3
ESA	2.18	2.14	2.09	2.05	2.01	1.97	1.93	1.89	1.85	18.1	108.9
LAC	2.01	1.97	1.93	1.89	1.85	1.82	1.78	1.75	1.71	16.7	100.5
SA	9.60	9.41	9.22	9.03	8.85	8.68	8.50	8.33	8.17	79.8	479.9
SEA	9.11	8.93	8.75	8.58	8.41	8.24	8.07	7.91	7.75	75.8	455.7
WCA	2.17	2.13	2.09	2.04	2.00	1.96	1.92	1.89	1.85	18.1	108.6
Total	28.16	27.60	27.05	26.50	25.97	25.46	24.95	24.45	23.96	234.1	1,408.0

Rural households (million households)

Region	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total adopters	Total population
CWANA	0.667	0.653	0.640	0.628	0.615	0.603	0.591	0.579	0.567	5.5	33.3
ESA	0.520	0.509	0.499	0.489	0.479	0.470	0.460	0.451	0.442	4.3	26.0
LAC	0.577	0.566	0.554	0.543	0.532	0.522	0.511	0.501	0.491	4.8	28.9
SA	2.005	1.964	1.925	1.887	1.849	1.812	1.776	1.740	1.705	16.7	100.2
SEA	2.906	2.848	2.791	2.735	2.680	2.627	2.574	2.523	2.472	24.2	145.3
WCA	0.439	0.430	0.422	0.413	0.405	0.397	0.389	0.381	0.373	3.6	21.9
Total	7.113	6.971	6.831	6.695	6.561	6.430	6.301	6.175	6.052	59.1	355.7

Projected yield and yield stability gains

Table 2 provides an overview of yield and yield stability gains for 10 agricultural practices well supported by scientific literature. Average productivity gains across these agricultural practices are approximately 24 %. Gains in yield stability are possible in 5 of the 8 practices for which yield stability could be calculated with the available data. Notably, in some cases (e.g., improved varieties, alley cropping, reduced tillage), the risk of the yield under the new practice becoming less than the yield under conventional practice can approach or exceed 50%. This highlights the importance of understanding the performance of new practices under variable environmental conditions and bundling new practices with risk-reducing services; for example, improved varieties may be bundled with robust agronomic services, CIS, and accessible financial services.

Table 2 | Select examples of productivity, yield stability, and production risk when adopting new agricultural practices. *Source: Authors' calculation based on ERA v2.0 (forthcoming).*

New Practice	**Product yield**[1] (% change)	**Relative yield stability**[2] (ratio)	**Risk**[3] *P(yield < control)*
Organic fertilizer	45	-0.18	0.10
Inorganic fertilizer	78	-0.21	0.15
Water harvesting	30	-0.03	0.39
Mulch	19	0.05	0.36
Improved varieties[4]	11	–[5]	0.45
Green manure	8	-0.22	0.27
Improving livestock diets[6]	22	–	–
Alley cropping	9	-0.16	0.65
Crop rotation	16	0.11	0.35
Reduced tillage	4	0.17	0.54

[1] Yield and yield stability calculated relative to the conventional practice.
[2] Relative yield stability follows methods in Knapp and van der Heijden (2018)[5] , and is calculated as the log ratio of the coefficients of variation in yields over time of the new practice relative to conventional practices. The temporal dynamic captures performance under variable weather conditions. Values below 0 suggest the yields of the adaptation solution are more temporally stable and greater than 0 suggest the yields are less stable.
[3] Risk represents the probability of yield with the solution being less than mean of conventional practices.
[4] Data on improved varieties is scarce because improved varieties are the base practice for most agronomic studies. Hence, in the majority of experiments, the yield benefits of improved varieties are already factored into the observed of all other new practices.
[5] Not able to be calculated based on the data complied from the more than 2,000 papers included in ERA v2.0.
[6] Product yields include data for both meat and milk.

The bundling of practices can also boost economic benefits. For example, evidence clearly demonstrates that while improved varieties alone can improve yields, adequate agronomic management are required to fully realize potential gains. Based on CGIAR Adaptation Atlas and ERA data on value of production, yield gaps, and production costs, among others, we estimate that improved agronomic services bundled with improved varieties would increase the average net return on maize harvests by more than 400% as compared to that of improved varieties alone (Figure 4). This illustrates the overwhelming opportunity to both amplify productivity and support robust climate adaptation by bundling interventions (Pequeno et al., 2021; Falconnier et al., 2020).

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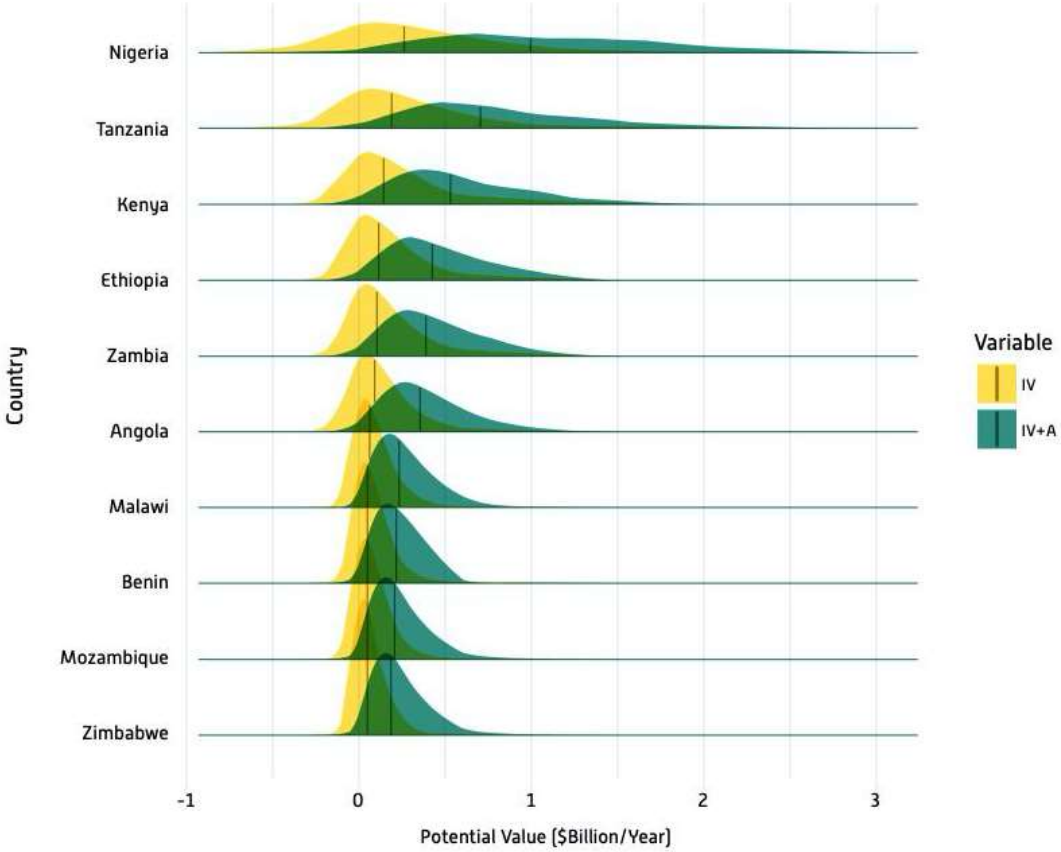
[5] https://www.nature.com/articles/s41467-018-05956-1

The estimated benefits of large integrative programs, such as MasAgro in Mexico and AClimateColombia in Colombia, further underscore this leverage point. In the case of MasAgro, annual yield gains of MasAgro farmers are approximately double that of non-MasAgro farmers at 46 vs. 24 kg/ha/year (CIMMYT 2021).

Figure 4 | The ten SSA countries with the highest projected gains in annual maize net returns from bundling improved varieties with improved agronomy (IV+A), versus improved varieties (IV) alone. Shaded areas represent uncertainty via a resampling approach. Solid bars are the median potential value of investment. *Source: Authors' calculation based on CGIAR Adaptation Atlas (forthcoming) and ERA (forthcoming).*



Assumptions and limitations

- We assume a constant adoption rate of 2% per year, which we believe represents an upper bound (Thornton and Herrero, 2010), and hence is useful to represent ambitious targets for CGIAR. We discount any beneficiaries in year *i* from subsequent years; however, in reality, adoption rates vary per year, sometimes substantially, depending on at least three factors: (i) presence of barriers to adoption and whether their effect and geographic variation is understood; (ii) whether the implemented program or project portfolio works to remove at least some of these barriers; and (iii) normal adoption dynamics, including early adopters within direct beneficiaries, spillovers, and disadoption. Adoption rate data covering a wide range of practices and practice portfolios is sparse, but some measures exist, such as for improved varieties (Fisher et al., 2015). Adoption constraints data are similarly limited (Arslan et al., 2020).
- One part of better capturing adoption relates to the refinement of the spheres of influence of One CGIAR initiatives. As *anchor* and *spillover* countries become clear for each CGIAR initiative and for the portfolio as a whole, more nuanced assumptions of adoption rates in these geographies can be developed.

- The Population Reference Bureau does not differentiate between rural and urban areas, nor does it provide a spatially disaggregated household size estimate that could be matched with the hazard layer. Future analyses could explore the use of higher resolution socio-economic datasets.
- We make our analysis adaptation-relevant by spatially intersecting data on rural population and climate hazards. In reality, the suitability of specific agricultural practices and practice portfolios, including CSA and CIS technologies, will vary geographically. The geographic domain of impact of a given One CGIAR initiative will depend on what programming they choose to scale. Determining the geographic domains of suitability of specific adaptation options and/or bundles would help improve the precision of future project beneficiary estimates.
- At present ERA only covers Africa.
- Data used in the analysis for bundling interventions (Figure 4), including farm-gate maize prices and production costs, are spatiotemporally variable and relatively scarce. Adding to the uncertainty, agronomic management options are broad, and may include many interventions with variable effects on productivity that also respond to local environmental and implementation context. We account for this uncertainty by presenting ranges of outcomes, illustrating both the most likely and extremes.

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