Climate-informed priorities for One CGIAR Regional Integrated Initiatives

Developed by Andy Jarvis (Alliance), Todd Rosenstock (CIFOR-ICRAF), Jawoo Koo (IFPRI), Phil Thornton (ILRI), Ana Maria Loboguerrero (Alliance), Bram Govaerts (CIMMYT), Julian Ramirez-Villegas (Alliance), Steven D. Prager (Alliance), Aniruddha Ghosh (Alliance), Keith Fuglie (USDA)

CGIAR

CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CCAFS

CGIAR Platform for Big Data in Agriculture

IFPRI INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

CIFOR

World Agroforestry Centre

CIMMYT International Maize and Wheat Improvement Center

Alliance

Bioversity International

CIAT International Center for Tropical Agriculture

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Introduction

The February 2021 RAFS-IAG meetings decided that the new One CGIAR's Regional Integrated Initiatives need to define their initial focus with a climate lens. This report summarizes a rapid assessment of climate-related challenges to food-, land- and water- systems across the 6 CGIAR regions. Based on the evidence, priority geographies and systems are proposed which provide a starting point for the Regional Initiatives design process. It then assesses the readiness of the Two Degree Initiative (2DI) regional challenges for their fit to the challenges, and potential to form the basis for developing the first batch of Regional Integrated Initiatives.

This rapid analysis consisted of the following[1]:

1. Identifying the primary climate hazards present in each CGIAR region
2. The exposure of people and agriculture to those climate hazards
3. The impact of future climate hazards to cropping and farming systems and regional assessment of agriculture contribution to poverty reduction and nutrition improvement
4. Disaggregated emissions data from the food system by region
5. Analyzed the performance of on-farm agricultural technologies and their barriers to adoption

We present the key results as a series of figures and tables grouped by One CGIAR region. The Annex contains data and maps clipped to the specific region for ease of use. Support during the design phase can fill in gaps unable to be addressed due to time constraints (e.g., vulnerability). The data presented here can also be combined with integrated assessments and strategic foresight to assess likely impacts in each region, and also a methodology is provided to support an evidence based and inclusive design process to further develop each initiative.

This report is organized in the following sections: Sect. 1 presents the key global adaptation and mitigation challenges; Sect. 2 explores the solution space; Sect. 3 dives into the region-specific results; Sect. 4 reviews the alignment of the two-degree initiative (2DI) with the region-specific results; Sect. 5 proposes a design process for the integrated initiatives; and Sect. 6 concludes with specific programmatic recommendations for initiative design. Methods associated with Sect. 1–3 are described in Annex 1.

[1] Methods are described in Annex 1.

Section 1: Key adaptation and mitigation challenges

We assessed the primary climate challenges facing each region using the IPCC Risk Framework (Box 1). The risk is determined by the interactions between hazards, vulnerability and exposure. In this definition, hazards encompass both extreme weather events (e.g. a one-day tropical storm) and slow climate trends (e.g. the annual average temperature increasing over decades). The analysis leverages off-the-shelf CCAFS datasets and analytical capacity developed under the Bill and Melinda Gates Foundation funded Digital Atlas of Adaptation grant (hereafter 'The Atlas') and other CCAFS aligned projects. Though The Atlas is not formally released yet, the datasets are finalized and were made available for the analysis.

IPCC (2014) Risk Framework

Risk is the "potential for consequences where something of value is at stake and where the outcome is uncertain", determined by the interaction of *hazard*, *exposure*, and *vulnerability*.

Hazard: Potential occurrence of a physical event that may cause damage or loss of assets, life, or services and resources.

Exposure: Presence of people, systems, resources, assets, etc., that can be affected.

Vulnerability: Propensity to be affected encompassed by the adaptive capacity and sensitivity of people or systems

Box 1 – The IPCC Risk Framework

Figure 1 | **Climate hazards to agriculture, present and futures, based on Thornton (unpublished).** Analysis describing rainfall variability (V), floods (F), drought (D), temperatures (T), growing season reductions (R), and combinations of the hazards under RCP8.5 clearly shows that climate hazards are both ubiquitous and place-based. Integrated regional program design should therefore take account of the diversity of hazards. However, as the geographic location and coverage of these hazards varies across regions, the RIIs should programmatically address those hazards which have the greatest effect on agricultural livelihoods. For example, much of Sub-Saharan Africa and South Asia will need to build resilience to high growing season temperature while Central America faces primarily high risks of floods and growing season reductions.

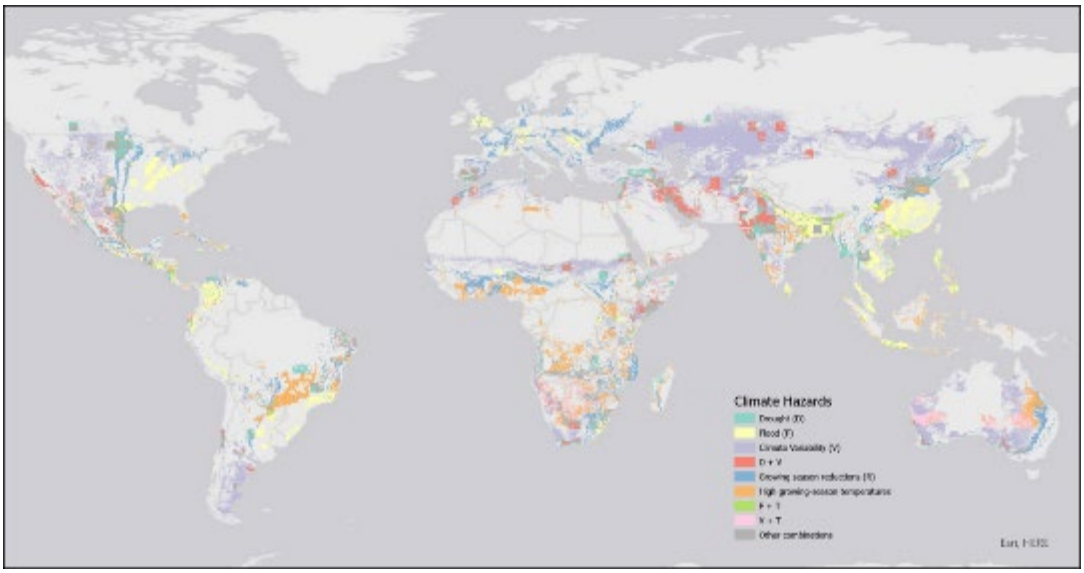
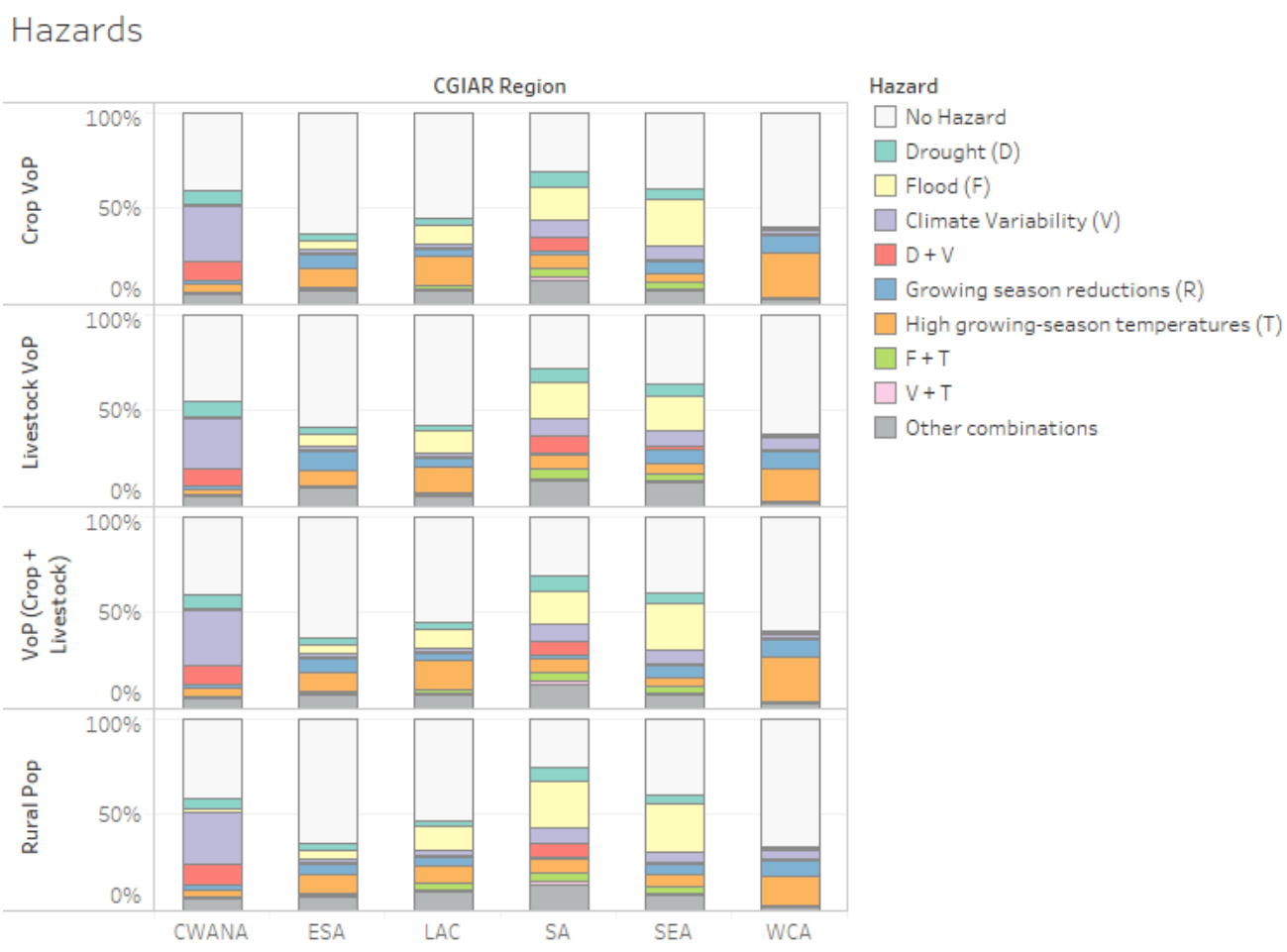


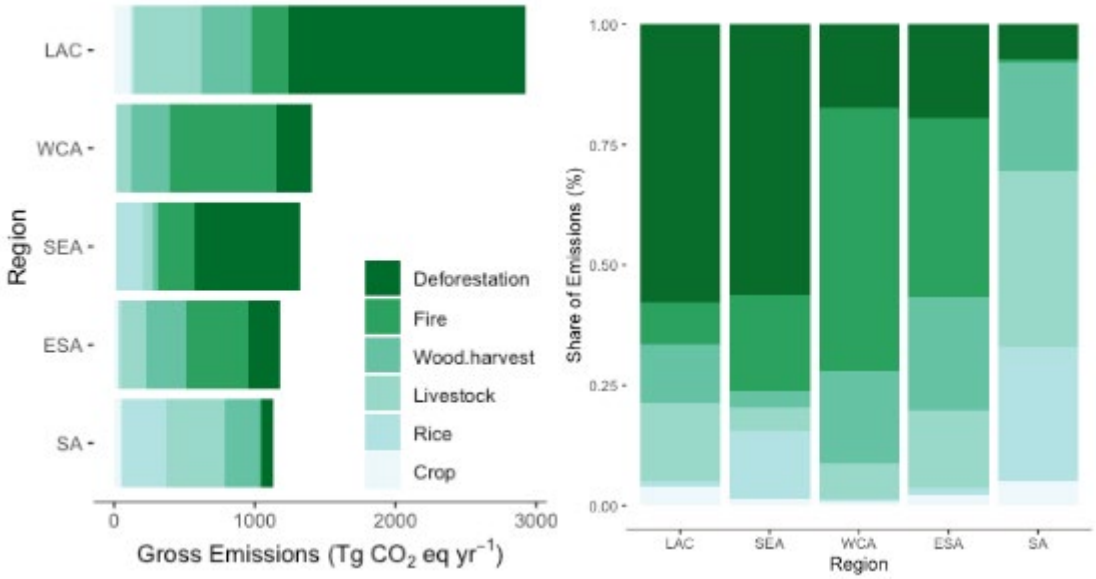
Figure 2 | Predominant climate related hazards and their relative distribution within each CGIAR region, expressed with respect to the level of exposure of value of production. Hazards presented in Figure 1 were overlaid with datasets from the MapSPAM[2] on Value of Production (VoP) for both crops and for livestock, and for rural population.

One important result related to Fig. 2 is that there is consistency in relation to the exposure of crops, livestock and people to these different hazards. Furthermore, a clear picture emerges with respect to the share of crop and livestock production value and population that are exposed to climate hazards (vs. not), as well as on the dominant climate factors that are likely to impact agricultural livelihoods. The region-specific sections presented later in this document provide a ranking of hazards for each region.



[2] International Food Policy Research Institute, 2020, "Spatially-Disaggregated Crop Production Statistics Data in Africa South of the Sahara for 2017", https://doi.org/10.7910/DVN/FSSKBW, Harvard Dataverse, V3

Figure 3 | Relative contribution of different agriculture and other land use (AFOLU) sources of emissions disaggregated by region. Value at top of graph show the total gross emission per region (Tg CO_2eq/year). These data show two dominant trends. One, Latin America and the Caribbean region are responsible for nearly double the gross annual emission than any other region, with deforestation accounting for nearly 50% of the emissions, followed by livestock emissions which account for another 20%. Two, livestock and rice production are the principal agricultural sources in Asia.



Section 2: Exploring solutions

Figure 4 | Identifying best fits: interactions driving performance of on-farm agricultural technologies varies. The Evidence for Resilient Agriculture (ERA) database includes data derived from 2,000 scientific publications on the performance of 100s of management practices and technologies applied alone or in combination in SSA. The data show key trends that the impacts of changing technologies vary by farming systems context. For example, below, the show the impact of practice interactions on yield. Interactions are categorized based on if they are antagonistic (i.e., using both together yields less than either alone), averaging (i.e., using both is equal to using either alone), subadditive (i.e., using both yield more than either along but less than them both combine) and superaddivitive (i.e., using both together yield more than both added individually).

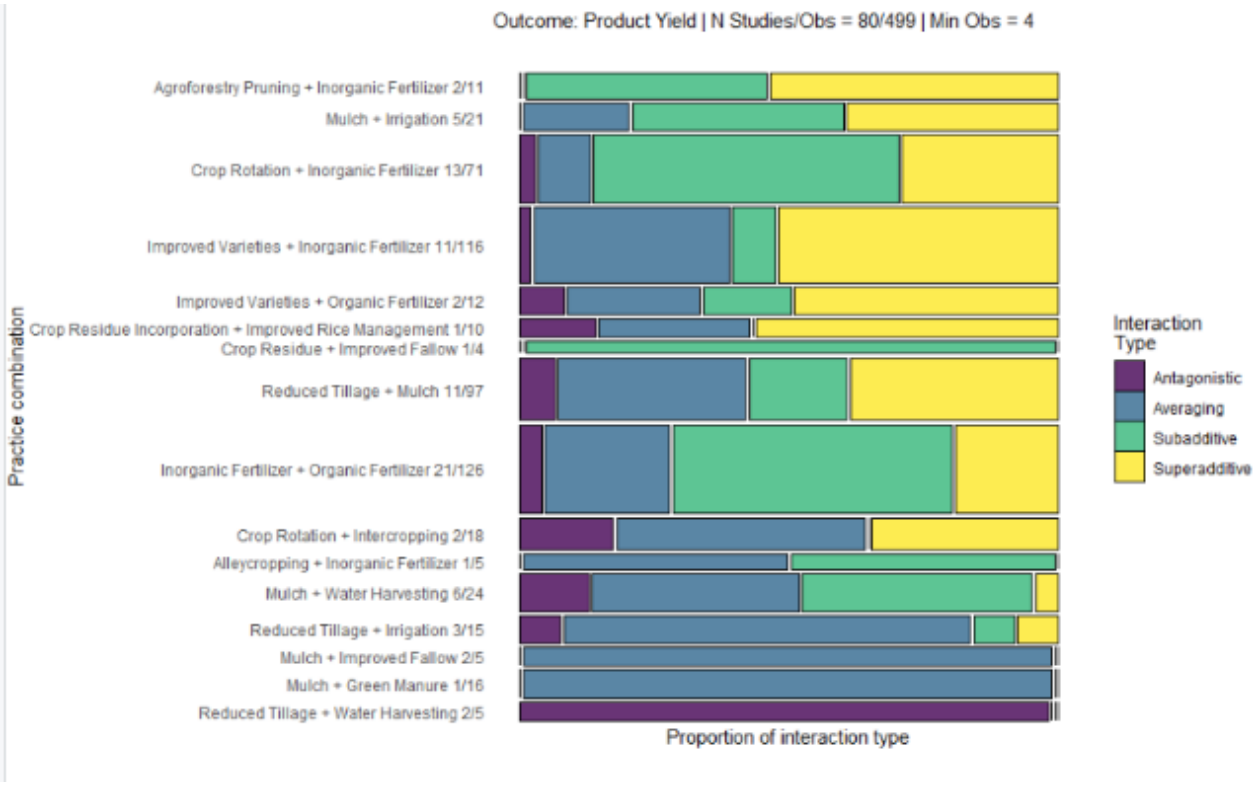


Figure 5 | The barriers to adoption of improved agriculture technologies in SSA. Colors indicate directional hypotheses of influence: dark green is positively related, light green is negatively related. Lines indicate confidence interval across 168 studies. If the confidence interval does not cross 0.5, then the factors can be considered to be associated with adoption more so than by chance. Values in parentheses are the number of times the determinant was included in the dataset. These types of data can be used to screen investments for major barriers to adoption and identify where complementary programming may help increase adoption. Data only available for SSA at this time (Arslan et al. in prep).

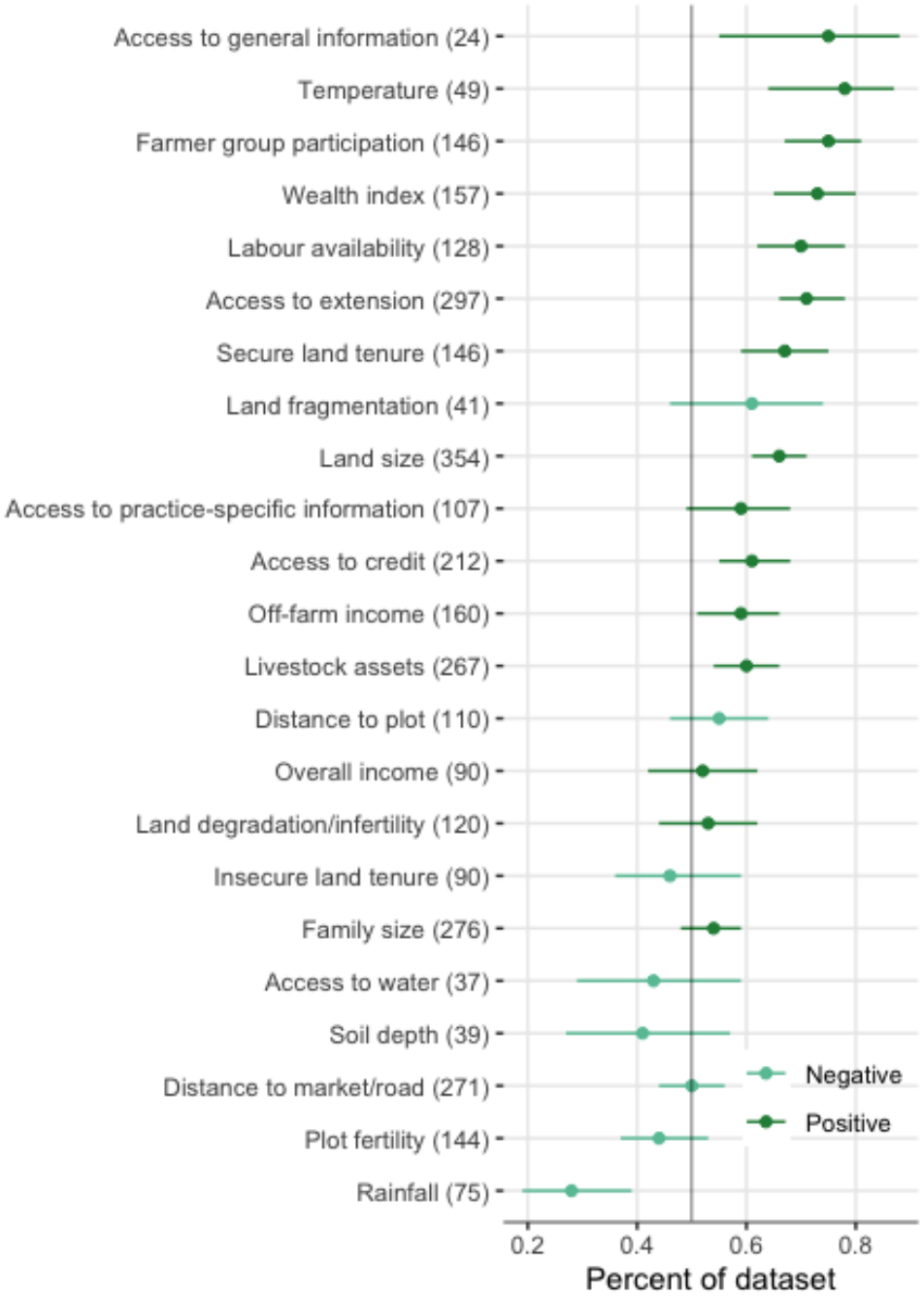
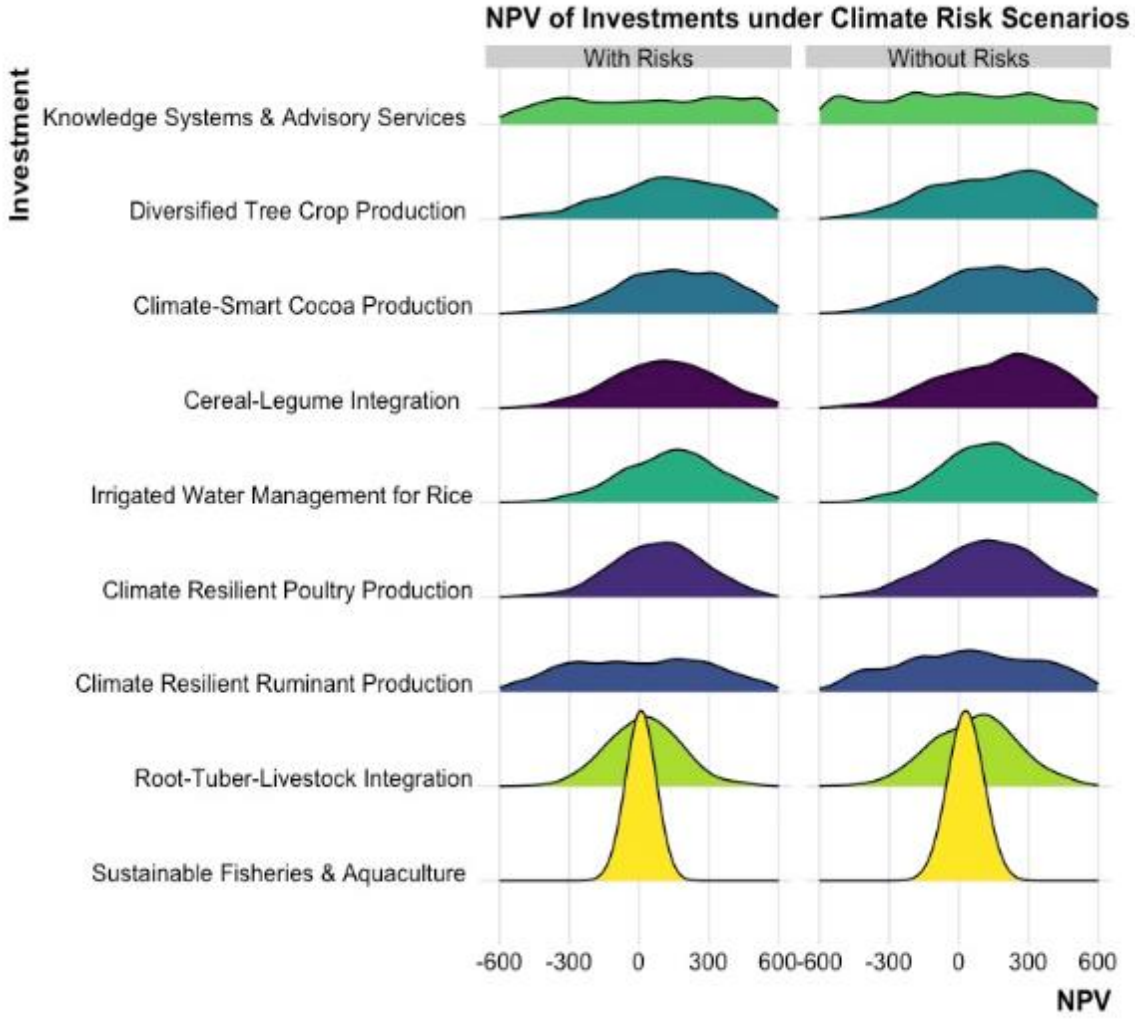
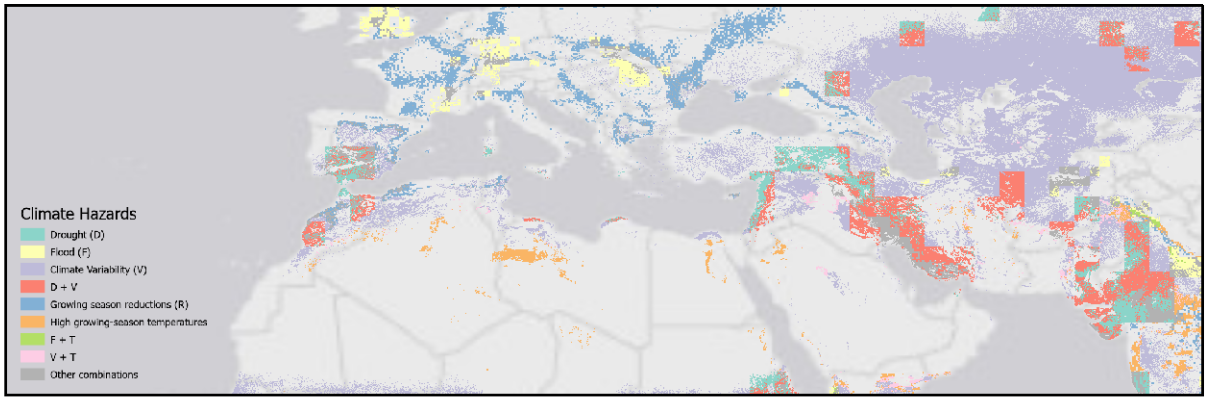


Figure 6 | Climate-informed investment design. Climate change presents risks to development investments; however, ex-ante cost-benefit analyses (CBA) rarely include climate risks. National-level CBA completed in collaboration with the World Bank integrated hazards, exposure, technology performance, adoption, and costs to estimate the most likely and extreme returns from agricultural investments. Note how the shape of the distributions of outcomes shift slightly when climate risks are included.



Section 3: Key regional results

Central, West Asia and North Africa (CWANA)



Summary of findings from IPCC reports

- Increased risk of heat-related mortality (high confidence)
- Increased water scarcity with impacts on food security, livelihoods and the economy (high confidence)

Modelled climate change impacts

9.9% less climatically suitable cropland

-3% wheat yield reduction

-12% maize yield reduction

Digital readiness

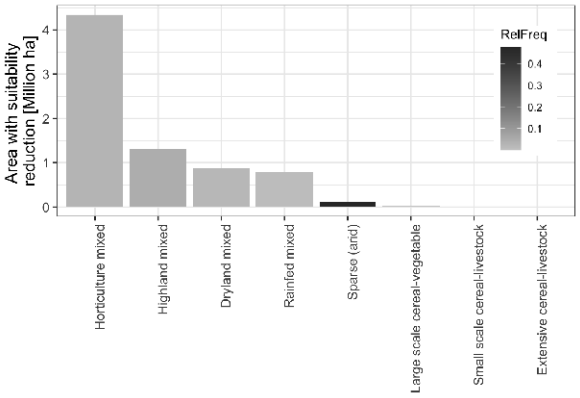
72% area with 2G, 3G or 4G network coverage

27% area with 3G or 4G network coverage

26% hazard exposed area suitable for climate information services

Top 5 climate hazards

1. Climate variability (135b US)
2. Drought + Climate variability (45.6b US)
3. Drought (39.7b US)
4. High temperature (14b US)
5. Growing season reductions (11.5b US)

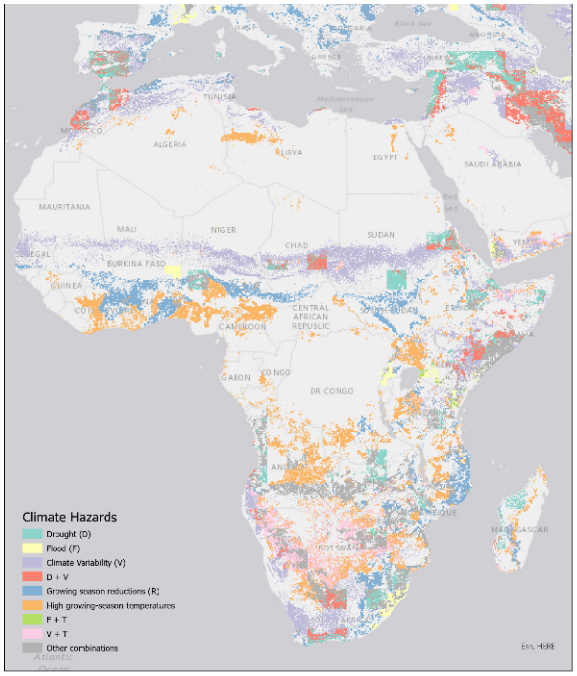


CWANA Values and Value Shares of Commodity Production (average annual gross value of production 2017-2019)

Commodity	Central, West Asia & North Africa (CWANA)					
	Value (million 2015 I$)			Value Share (%)		
	Total	Poverty	Stunting	Total	Poverty	Stunting
Cereal Grains						
Rice	3,590	180	78	1.5	0.9	2.0
Wheat	18,019	1,149	272	7.7	5.7	7.1
Maize	3,321	117	59	1.4	0.6	1.5
Millet	964	118	54	0.4	0.6	1.4
Sorghum	1,660	202	93	0.7	1.0	2.4
Barley	3,793	35	41	1.6	0.2	1.1
Roots, Tubers & Bananas						
Potato	8,079	593	130	3.4	2.9	3.4
Cassava	0	0	0	0.0	0.0	0.0
Yam	49	6	3	0.0	0.0	0.1
Sweet Potato	152	10	6	0.1	0.0	0.1
Taro (cocoyam)	2	0	1	0.0	0.0	0.0
Banana	1,276	67	39	0.5	0.3	1.0
Plantain	0	0	0	0.0	0.0	0.0
Oilseeds & Pulses						
Groundnut	2,181	235	107	0.9	1.2	2.8
Soybean	145	3	1	0.1	0.0	0.0
Sesame	1,294	149	68	0.6	0.7	1.8
Beans (*phaseolus*)	507	8	7	0.2	0.0	0.2
Chickpea (*cicer*)	744	17	9	0.3	0.1	0.2
Cowpea (*vigna unguiculata*)	75	10	4	0.0	0.0	0.1
Pigeonpea (*cajanus*)	0	0	0	0.0	0.0	0.0
Lentil (*lens*)	431	3	5	0.2	0.0	0.1
Smallholder Cash Crops						
Cotton	6,456	1,775	83	2.7	8.7	2.1
Coffee	41	7	3	0.0	0.0	0.1
Coconut	0	0	0	0.0	0.0	0.0
Cocoa	0	0	0	0.0	0.0	0.0
Cashew	0	0	0	0.0	0.0	0.0
Vegetables & Melons						
Solanum (tomato, eggplant)	19,156	994	263	8.2	4.9	6.8
Allum (onion, shallot, garlic, leek)	6,882	574	145	2.9	2.8	3.8
Cucurbit (cucumber, pumpkin, melon)	6,975	468	102	3.0	2.3	2.6
Brassica (cabbage, cauliflower, broccoli)	999	126	13	0.4	0.6	0.3
Okra	526	42	21	0.2	0.2	0.6
Legume vegetables (green beans, peas)	905	14	13	0.4	0.1	0.3
Leafy vegetables (lettuce, spinach)	412	3	3	0.2	0.0	0.1
Vegetable, other	8,453	1,171	129	3.6	5.8	3.3
Tree Fruits						
Citrus (oranges, tangerines, lemons, other)	12,786	330	224	5.4	1.6	5.8
Mango	1,602	123	64	0.7	0.6	1.7
Pineapple	1	0	0	0.0	0.0	0.0
Papaya	10	1	1	0.0	0.0	0.0
Other tropical fruit	3,542	71	54	1.5	0.4	1.4
Other temperate fruit	13,192	989	164	5.6	4.9	4.3
Cultivated Forage Crops	238	5	6	0.1	0.0	0.2
Livestock						
Dairy (milk)	27,196	3,317	372	11.6	16.3	9.6
Cattle (meat)	21,208	3,201	364	9.0	15.8	9.4
Small ruminants (meat,milk, wool)	30,807	3,354	491	13.1	16.5	12.7
Poultry (meat & eggs)	25,521	717	321	10.9	3.5	8.3
Pigs	239	13	1	0.1	0.1	0.0
Aquaculture - Freshwater fish						
Carp	391	50	10	0.2	0.2	0.3
Tilapia	1,341	51	39	0.6	0.3	1.0
Misc freshwater fish	38	12	1	0.0	0.1	0.0
Cereal Grains	31,347	1,802	596	13.3	8.9	15.5
Roots, Tubers & Bananas	9,558	675	178	4.1	3.3	4.6
Oilseeds & Pulses	5,376	425	203	2.3	2.1	5.2
Smallholder Cash Crops	6,497	1,782	85	2.8	8.8	2.2
Vegetables & Melons	44,308	3,392	690	18.9	16.7	17.9
Tree Fruits	31,132	1,515	507	13.3	7.5	13.1
Livestock	104,971	10,603	1,549	44.7	52.2	40.2
Fish	1,771	113	50	0.8	0.6	1.3
ALL CROPS (x plantation)	128,219	9,591	2,260	54.6	47.2	58.6
ALL LIVESTOCK & FISH	106,742	10,716	1,599	45.4	52.8	41.4
ALL AGRICULTURE (x plantation)	234,961	20,307	3,859	100.0	100.0	100.0

Poverty = value weighted by $1.9/capita/day poverty headcount; stunting = value weighted by prevalence of child stunting.
Value of forage crops included in value of livestock production.

West and Central Africa (WCA)



Summary of findings from IPCC reports

- Major water scarcity issues due to ongoing overexploitation and degradation and increased demand in the future, leading to food insecurity, and exacerbating migration and conflict (high confidence)
- Reduced crop productivity associated with heat and drought stress, with strong adverse effects on livelihoods and food security (high confidence)
- Increased pest and disease damage and flood impacts on food system infrastructure (high confidence)
- Changes in the incidence and geographic range of vector- and water-borne diseases (medium confidence)

Top 5 climate hazards

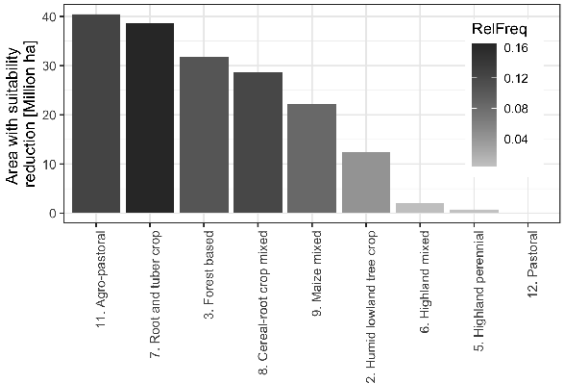
1. High temperature (26.6b US)
2. Growing season reductions (12.4b US)
3. Climate variability (5.6b US)
4. Drought (1.4b US)
5. Flood (0.7b USD)

Modelled climate change impacts

23.2% less climatically suitable cropland

-15% wheat yield reduction

-30% maize yield reduction



Digital readiness

52% area with 2G, 3G or 4G network coverage

10% area with 3G or 4G network coverage

66% hazard exposed area suitable for climate information services

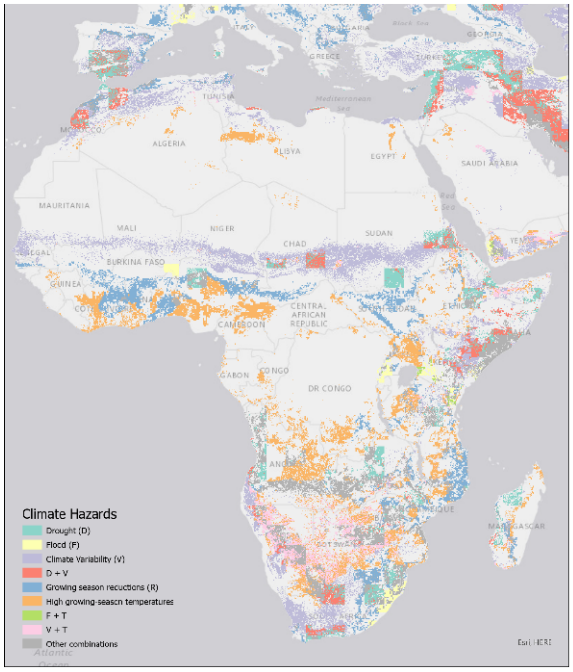
Greenhouse gas emissions

1,388 Tg CO_2 eq / yr **Total**

Source	%
Harvest	35.3
Fire	24.1
Deforestation	18.7
Livestock	18.6
Crop	2.2
Rice	1.1

WCA Values and Value Shares of Commodity Production (average annual gross value of production 2017-2019)						
Commodity	West & Central Africa (WCA)					
	Value (million 2015 I$)			Value Share (%)		
	Total	Poverty	Stunting	Total	Poverty	Stunting
Cereal Grains						
Rice	8,647	3,530	450	5.4	5.7	5.4
Wheat	27	12	2	0.0	0.0	0.0
Maize	6,227	2,610	335	3.9	4.2	4.0
Millet	4,782	2,078	344	3.0	3.4	4.1
Sorghum	3,523	1,453	227	2.2	2.4	2.7
Barley	1	0	0	0.0	0.0	0.0
Roots, Tubers & Bananas						
Potato	771	325	46	0.5	0.5	0.6
Cassava	22,128	10,106	1,277	13.7	16.4	15.2
Yam	19,303	6,933	1,042	12.0	11.2	12.4
Sweet Potato	1,814	780	110	1.1	1.3	1.3
Taro (cocoyam)	755	93	121	0.5	0.2	1.4
Banana	2,635	1,256	159	1.6	2.0	1.9
Plantain	7,670	2,901	379	4.7	4.7	4.5
Oilseeds & Pulses						
Groundnut	8,270	3,290	458	5.1	5.3	5.5
Soybean	488	186	27	0.3	0.3	0.3
Sesame	1,369	554	81	0.8	0.9	1.0
Beans (*phaseolus*)	1,442	628	77	0.9	1.0	0.9
Chickpea (*cicer*)	1	1	0	0.0	0.0	0.0
Cowpea (*vigna unguiculata*)	2,465	1,010	169	1.5	1.6	2.0
Pigeonpea (*cajanus*)	5	4	0	0.0	0.0	0.0
Lentil (*lens*)	0	0	0	0.0	0.0	0.0
Smallholder Cash Crops						
Cotton	3,098	1,338	149	1.9	2.2	1.8
Coffee	472	202	23	0.3	0.3	0.3
Coconut	148	41	6	0.1	0.1	0.1
Cocoa	5,473	1,466	194	3.4	2.4	2.3
Cashew	1,511	588	61	0.9	1.0	0.7
Vegetables & Melons						
Solanum (tomato, eggplant)	2,999	1,080	166	1.9	1.8	2.0
Allum (onion, shallot, garlic, leek)	1,924	792	123	1.2	1.3	1.5
Cucurbit (cucumber, pumpkin, melon)	578	227	26	0.4	0.4	0.3
Brassica (cabbage, cauliflower, broccoli)	221	102	16	0.1	0.2	0.2
Okra	2,461	969	142	1.5	1.6	1.7
Legume vegetables (green beans, peas)	39	15	2	0.0	0.0	0.0
Leafy vegetables (lettuce, spinach)	81	37	6	0.1	0.1	0.1
Vegetable, other	5,731	2,305	335	3.5	3.7	4.0
Tree Fruits						
Citrus (oranges, tangerines, lemons, other)	5,784	2,334	328	3.6	3.8	3.9
Mango	1,774	789	100	1.1	1.3	1.2
Pineapple	1,731	667	94	1.1	1.1	1.1
Papaya	402	187	25	0.2	0.3	0.3
Other tropical fruit	180	75	9	0.1	0.1	0.1
Other temperate fruit	1,273	517	79	0.8	0.8	0.9
Cultivated Forage Crops	7	3	0	0.0	0.0	0.0
Livestock						
Dairy (milk)	1,428	576	86	0.9	0.9	1.0
Cattle (meat)	7,483	3,108	438	4.6	5.0	5.2
Small ruminants (meat,milk, wool)	19,990	4,759	465	12.4	7.7	5.5
Poultry (meat & eggs)	2,883	1,100	148	1.8	1.8	1.8
Pigs	1,321	570	75	0.8	0.9	0.9
Aquaculture - Freshwater fish						
Carp	35	14	0	0.0	0.0	0.0
Tilapia	124	28	4	0.1	0.0	0.1
Misc freshwater fish	4	1	1	0.0	0.0	0.0
Cereal Grains	23,206	9,683	1,359	14.4	15.7	16.2
Roots, Tubers & Bananas	55,075	22,395	3,135	34.1	36.3	37.3
Oilseeds & Pulses	14,041	5,672	813	8.7	9.2	9.7
Smallholder Cash Crops	10,702	3,635	434	6.6	5.9	5.2
Vegetables & Melons	14,035	5,528	817	8.7	9.0	9.7
Tree Fruits	11,144	4,571	635	6.9	7.4	7.6
Livestock	33,106	10,114	1,212	20.5	16.4	14.4
Fish	162	43	5	0.1	0.1	0.1
ALL CROPS (x plantation)	128,203	51,483	7,192	79.4	83.5	85.5
ALL LIVESTOCK & FISH	33,268	10,157	1,217	20.6	16.5	14.5
ALL AGRICULTURE (x plantation)	161,471	61,641	8,409	100.0	100.0	100.0
Poverty = value weighted by $1.9/capita/day poverty headcount; stunting = value weighted by prevalence of child stunting.						
Value of forage crops included in value of livestock production.						

East and Southern Africa (ESA)



Summary of findings from IPCC reports

- Major water scarcity issues due to ongoing overexploitation and degradation and increased demand in the future (high confidence)
- Reduced crop productivity associated with heat and drought stress, with strong adverse effects on livelihoods and food security (high confidence)
- Increased pest and disease damage and flood impacts on food system infrastructure (high confidence)
- Changes in the incidence and geographic range of vector- and water-borne diseases (medium confidence)

Top 5 climate hazards

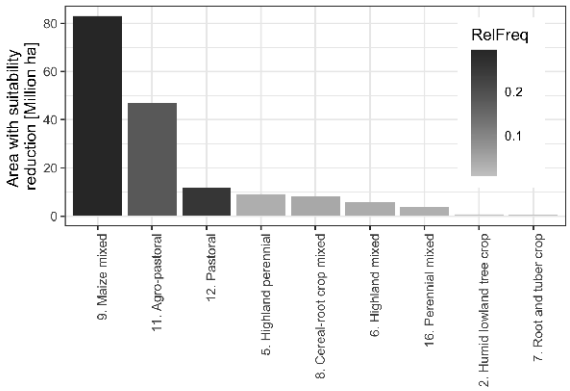
1. Growing season reductions (16b US)
2. High temperature (14b US)
3. Flood (9.5b US)
4. Drought (7.0b US)
5. Climate variability (3.5b USD)

Modelled climate change impacts

33.5% less climatically suitable cropland

-15% wheat yield reduction

-15% maize yield reduction



Digital readiness

65% area with 2G, 3G or 4G network coverage

37% area with 3G or 4G network coverage

67% hazard exposed area suitable for climate information services

Greenhouse gas emissions

1,222
Tg CO_2 eq / yr
Total

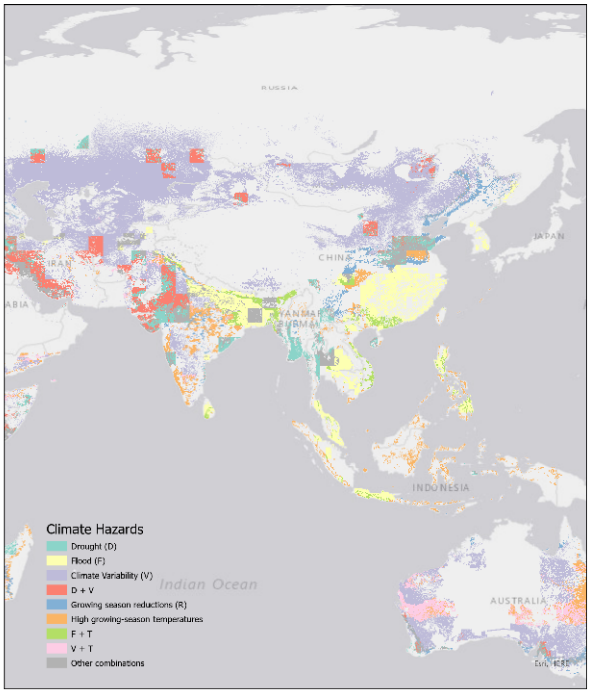
Source	%
Harvest	37.7
Livestock	22.3
Fire	21.2
Deforestation	15.8
Crop	2.8
Rice	0.2

ESA Values and Value Shares of Commodity Production (average annual gross value of production 2017-2019)

Commodity	East & Southern Africa (ESA)					
	Value (million 2015 I$)			Value Share (%)		
	Total	Poverty	Stunting	Total	Poverty	Stunting
Cereal Grains						
Rice	3,243	2,046	189	2.9	4.6	3.9
Wheat	1,715	524	83	1.5	1.2	1.7
Maize	9,336	3,509	428	8.3	7.9	8.7
Millet	483	182	24	0.4	0.4	0.5
Sorghum	1,145	457	61	1.0	1.0	1.3
Barley	510	159	26	0.5	0.4	0.5
Roots, Tubers & Bananas						
Potato	2,362	992	109	2.1	2.2	2.2
Cassava	4,489	2,652	271	4.0	6.0	5.5
Yam	50	23	3	0.0	0.1	0.1
Sweet Potato	3,757	2,116	215	3.3	4.8	4.4
Taro (cocoyam)	139	44	14	0.1	0.1	0.3
Banana	3,857	1,985	216	3.4	4.5	4.4
Plantain	2,189	1,080	124	2.0	2.4	2.5
Oilseeds & Pulses						
Groundnut	1,443	742	78	1.3	1.7	1.6
Soybean	796	251	30	0.7	0.6	0.6
Sesame	1,570	699	84	1.4	1.6	1.7
Beans (*phaseolus*)	3,840	1,814	209	3.4	4.1	4.3
Chickpea (*cicer*)	366	126	20	0.3	0.3	0.4
Cowpea (*vigna unguiculata*)	294	126	16	0.3	0.3	0.3
Pigeonpea (*cajanus*)	530	326	30	0.5	0.7	0.6
Lentil (*lens*)	101	34	6	0.1	0.1	0.1
Smallholder Cash Crops						
Cotton	770	339	39	0.7	0.8	0.8
Coffee	2,033	835	111	1.8	1.9	2.3
Coconut	155	78	9	0.1	0.2	0.2
Cocoa	88	44	5	0.1	0.1	0.1
Cashew	619	377	45	0.6	0.9	0.9
Vegetables & Melons						
Solanum (tomato, eggplant)	1,583	762	79	1.4	1.7	1.6
Allum (onion, shallot, garlic, leek)	998	377	47	0.9	0.8	1.0
Cucurbit (cucumber, pumpkin, melon)	367	170	17	0.3	0.4	0.3
Brassica (cabbage, cauliflower, broccoli)	401	159	18	0.4	0.4	0.4
Okra	12	5	0	0.0	0.0	0.0
Legume vegetables (green beans, peas)	63	23	3	0.1	0.1	0.1
Leafy vegetables (lettuce, spinach)	45	15	2	0.0	0.0	0.0
Vegetable, other	3,383	1,572	174	3.0	3.5	3.5
Tree Fruits						
Citrus (oranges, tangerines, lemons, other)	4,055	1,833	190	3.6	4.1	3.9
Mango	2,136	1,253	115	1.9	2.8	2.3
Pineapple	569	290	28	0.5	0.7	0.6
Papaya	107	49	5	0.1	0.1	0.1
Other tropical fruit	426	222	22	0.4	0.5	0.4
Other temperate fruit	1,741	595	74	1.6	1.3	1.5
Cultivated Forage Crops	1,239	327	41	1.1	0.7	0.8
Livestock						
Dairy (milk)	8,681	3,270	395	7.7	7.4	8.1
Cattle (meat)	15,118	5,498	649	13.5	12.4	13.2
Small ruminants (meat,milk, wool)	18,260	3,848	317	16.3	8.7	6.5
Poultry (meat & eggs)	6,295	1,876	228	5.6	4.2	4.7
Pigs	1,818	890	91	1.6	2.0	1.9
Aquaculture - Freshwater fish						
Carp	4	2	0	0.0	0.0	0.0
Tilapia	176	83	4	0.2	0.2	0.1
Misc freshwater fish	64	27	1	0.1	0.1	0.0
Cereal Grains	16,432	6,876	811	14.6	15.5	16.6
Roots, Tubers & Bananas	16,843	8,892	951	15.0	20.0	19.4
Oilseeds & Pulses	8,942	4,119	472	8.0	9.3	9.6
Smallholder Cash Crops	3,665	1,673	208	3.3	3.8	4.2
Vegetables & Melons	6,853	3,083	339	6.1	6.9	6.9
Tree Fruits	9,033	4,242	433	8.1	9.6	8.8
Livestock	50,172	15,382	1,680	44.7	34.7	34.3
Fish	243	112	5	0.2	0.3	0.1
ALL CROPS (x plantation)	61,768	28,885	3,214	55.1	65.1	65.6
ALL LIVESTOCK & FISH	50,415	15,494	1,685	44.9	34.9	34.4
ALL AGRICULTURE (x plantation)	112,184	44,379	4,899	100.0	100.0	100.0

Poverty = value weighted by $1.9/capita/day poverty headcount; stunting = value weighted by prevalence of child stunting.
Value of forage crops included in value of livestock production.

South East Asia (SEA)



Summary of findings from IPCC reports

- Increased flooding leading to widespread damage to infrastructure, livelihoods, and settlements (medium confidence)
- Increased risk of drought-related water and food shortage causing malnutrition (high confidence)

Top 5 climate hazards

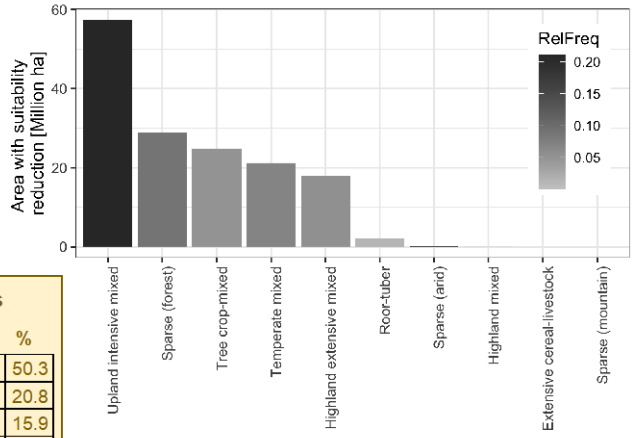
1. Flood (378b US)
2. Climate variability (157.4 US)
3. Growing season reductions (131b US)
4. Drought (118b US)
5. High temperature (107b USD)

Modelled climate change impacts

21.6% less climatically suitable cropland

-5% wheat yield reduction

-15% maize yield reduction



Digital readiness

63% area with 2G, 3G or 4G network coverage

19% area with 3G or 4G network coverage

71% hazard exposed area suitable for climate information services

Greenhouse gas emissions

1,415
Tg CO_2 eq / yr
Total

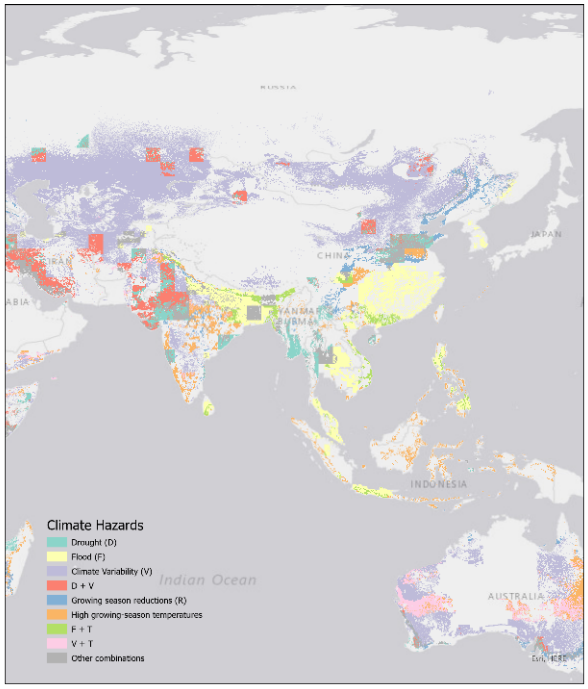
Source	%
Deforestation	50.3
Rice	20.8
Fire	15.9
Livestock	7.7
Crop	3.4
Harvest	1.9

SEA Values and Value Shares of Commodity Production (average annual gross value of production 2017-2019)

Commodity	Southeast Asia					
	Value (million 2015 I$)			Value Share (%)		
	Total	Poverty	Stunting	Total	Poverty	Stunting
Cereal Grains						
Rice	76,436	2,041	1,741	29.7	20.8	30.1
Wheat	28	0	1	0.0	0.0	0.0
Maize	10,381	381	267	4.0	3.9	4.6
Millet	56	1	1	0.0	0.0	0.0
Sorghum	44	1	1	0.0	0.0	0.0
Barley	27	0	0	0.0	0.0	0.0
Roots, Tubers & Bananas						
Potato	583	17	15	0.2	0.2	0.3
Cassava	10,967	219	214	4.3	2.2	3.7
Yam	120	41	7	0.0	0.4	0.1
Sweet Potato	1,008	94	32	0.4	1.0	0.5
Taro (cocoyam)	55	6	10	0.0	0.1	0.2
Banana	6,953	498	204	2.7	5.1	3.5
Plantain	1,680	78	49	0.7	0.8	0.9
Oilseeds & Pulses						
Groundnut	1,834	42	45	0.7	0.4	0.8
Soybean	484	13	13	0.2	0.1	0.2
Sesame	956	16	23	0.4	0.2	0.4
Beans (*phaseolus*)	4,705	72	116	1.8	0.7	2.0
Chickpea (*cicer*)	363	5	9	0.1	0.1	0.2
Cowpea (*vigna unguiculata*)	37	1	1	0.0	0.0	0.0
Pigeonpea (*cajanus*)	312	4	8	0.1	0.0	0.1
Lentil (*lens*)	1	0	0	0.0	0.0	0.0
Smallholder Cash Crops						
Cotton	312	5	8	0.1	0.1	0.1
Coffee	5,638	254	137	2.2	2.6	2.4
Coconut	6,088	339	177	2.4	3.5	3.1
Cocoa	1,141	66	34	0.4	0.7	0.6
Cashew	616	22	15	0.2	0.2	0.3
Vegetables & Melons						
Solanum (tomato, eggplant)	1,117	40	29	0.4	0.4	0.5
Allum (onion, shallot, garlic, leek)	1,763	47	44	0.7	0.5	0.8
Cucurbit (cucumber, pumpkin, melon)	950	34	22	0.4	0.3	0.4
Brassica (cabbage, cauliflower, broccoli)	725	20	17	0.3	0.2	0.3
Okra	84	2	2	0.0	0.0	0.0
Legume vegetables (green beans, peas)	399	11	9	0.2	0.1	0.2
Leafy vegetables (lettuce, spinach)	71	1	2	0.0	0.0	0.0
Vegetable, other	13,332	544	324	5.2	5.5	5.6
Tree Fruits						
Citrus (oranges, tangerines, lemons, other)	12,677	497	290	4.9	5.1	5.0
Mango	4,408	109	90	1.7	1.1	1.5
Pineapple	3,175	106	70	1.2	1.1	1.2
Papaya	466	17	12	0.2	0.2	0.2
Other tropical fruit	2,930	101	66	1.1	1.0	1.1
Other temperate fruit	4,135	295	111	1.6	3.0	1.9
Cultivated Forage Crops	238	5	6	0.1	0.1	0.1
Livestock						
Dairy (milk)	2,262	36	46	0.9	0.4	0.8
Cattle (meat)	7,460	223	181	2.9	2.3	3.1
Small ruminants (meat,milk, wool)	14,780	1,995	62	5.7	20.3	1.1
Poultry (meat & eggs)	30,868	773	698	12.0	7.9	12.1
Pigs	16,488	512	368	6.4	5.2	6.4
Aquaculture - Freshwater fish						
Carp	2,249	46	58	0.9	0.5	1.0
Tilapia	2,415	83	62	0.9	0.8	1.1
Misc freshwater fish	3,783	113	100	1.5	1.2	1.7
Cereal Grains	86,972	2,424	2,012	33.8	24.7	34.7
Roots, Tubers & Bananas	21,365	953	531	8.3	9.7	9.2
Oilseeds & Pulses	8,691	153	215	3.4	1.6	3.7
Smallholder Cash Crops	13,796	687	371	5.4	7.0	6.4
Vegetables & Melons	18,440	700	448	7.2	7.1	7.7
Tree Fruits	27,791	1,125	638	10.8	11.4	11.0
Livestock	71,857	3,539	1,356	27.9	36.0	23.4
Fish	8,446	242	220	3.3	2.5	3.8
ALL CROPS (x plantation)	177,054	6,041	4,215	68.8	61.5	72.8
ALL LIVESTOCK & FISH	80,304	3,782	1,575	31.2	38.5	27.2
ALL AGRICULTURE (x plantation)	257,358	9,823	5,790	100.0	100.0	100.0

Poverty = value weighted by $1.9/capita/day poverty headcount; stunting = value weighted by prevalence of child stunting.
Value of forage crops included in value of livestock production.

South Asia (SA)



Summary of findings from IPCC reports

- Increased risk of heat-related mortality (high confidence)
- Increased risk of drought-related water and food shortage causing malnutrition (high confidence)
- Climate variability and extremes and associated crop failure affect food stability, leading to price spikes, reduced affordability, with impacts on food security and nutrition (high confidence)

Top 5 climate hazards

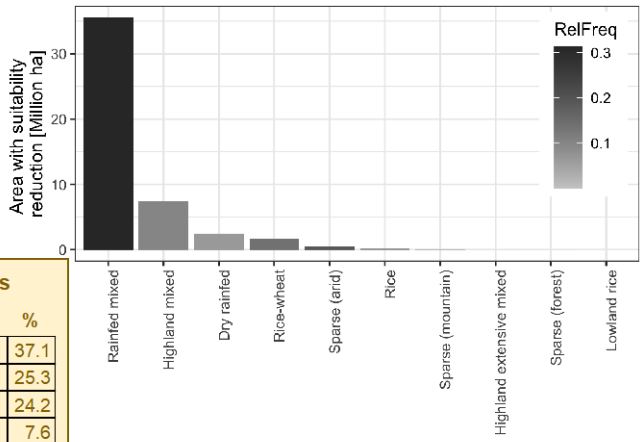
1. Flood (150b US)
2. Drought and climate variability (70.1 US)
3. Climate variability (69.5b US)
4. Drought (62.2b US)
5. High temperature (55.6b USD)

Modelled climate change impacts

26.7% less climatically suitable cropland

-16% wheat yield reduction

-30% maize yield reduction



Digital readiness

88% area with 2G, 3G or 4G network coverage

63% area with 3G or 4G network coverage

85% hazard exposed area suitable for climate information services

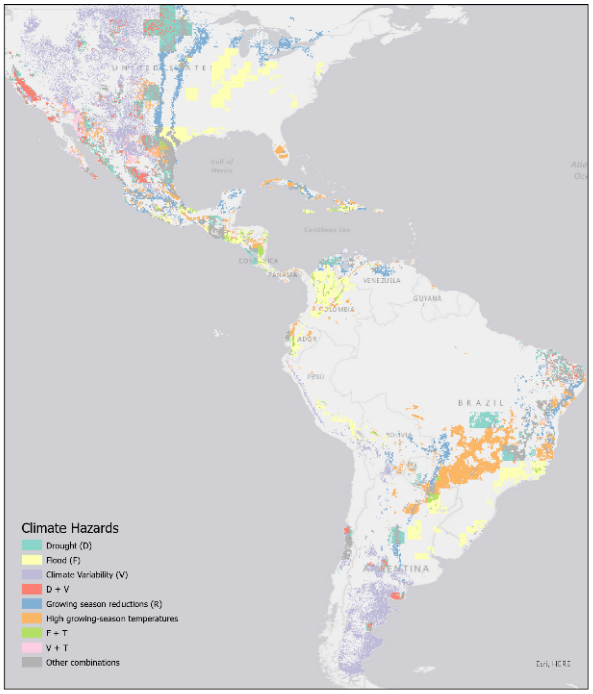
Greenhouse gas emissions

1,127
Tg CO_2 eq / yr
Total

Source	%
Livestock	37.1
Rice	25.3
Harvest	24.2
Deforestation	7.6
Crop	5.2
Fire	0.6

SA Values and Value Shares of Commodity Production (average annual gross value of production 2017-2019)						
Commodity	South Asia					
	Value (million 2015 I$)			Value Share (%)		
	Total	Poverty	Stunting	Total	Poverty	Stunting
Cereal Grains						
Rice	97,012	18,859	2,918	21.5	21.5	20.8
Wheat	30,578	5,712	1,026	6.8	6.5	7.3
Maize	8,070	1,465	266	1.8	1.7	1.9
Millet	2,906	621	90	0.6	0.7	0.6
Sorghum	1,118	242	34	0.2	0.3	0.2
Barley	352	77	11	0.1	0.1	0.1
Roots, Tubers & Bananas						
Potato	16,879	3,332	522	3.7	3.8	3.7
Cassava	727	154	21	0.2	0.2	0.1
Yam	0	0	0	0.0	0.0	0.0
Sweet Potato	346	71	10	0.1	0.1	0.1
Taro (cocoyam)	0	0	0	0.0	0.0	0.0
Banana	11,307	2,505	338	2.5	2.9	2.4
Plantain	298	11	5	0.1	0.0	0.0
Oilseeds & Pulses						
Groundnut	5,788	1,282	174	1.3	1.5	1.2
Soybean	4,816	1,079	144	1.1	1.2	1.0
Sesame	924	194	28	0.2	0.2	0.2
Beans (*phaseolus*)	4,717	1,036	143	1.0	1.2	1.0
Chickpea (*cicer*)	7,396	1,616	226	1.6	1.8	1.6
Cowpea (*vigna unguiculata*)	3	0	0	0.0	0.0	0.0
Pigeonpea (*cajanus*)	3,092	695	92	0.7	0.8	0.7
Lentil (*lens*)	1,222	252	37	0.3	0.3	0.3
Smallholder Cash Crops						
Cotton	19,862	3,618	677	4.4	4.1	4.8
Coffee	673	149	20	0.1	0.2	0.1
Coconut	2,727	531	76	0.6	0.6	0.5
Cocoa	33	7	1	0.0	0.0	0.0
Cashew	745	161	22	0.2	0.2	0.2
Vegetables & Melons						
Solanum (tomato, eggplant)	16,062	3,520	483	3.6	4.0	3.4
Allum (onion, shallot, garlic, leek)	12,265	2,509	379	2.7	2.9	2.7
Cucurbit (cucumber, pumpkin, melon)	1,775	335	56	0.4	0.4	0.4
Brassica (cabbage, cauliflower, broccoli)	4,275	932	128	0.9	1.1	0.9
Okra	5,877	1,301	178	1.3	1.5	1.3
Legume vegetables (green beans, peas)	2,074	447	62	0.5	0.5	0.4
Leafy vegetables (lettuce, spinach)	330	68	10	0.1	0.1	0.1
Vegetable, other	19,108	3,993	587	4.2	4.6	4.2
Tree Fruits						
Citrus (oranges, tangerines, lemons, other)	24,359	4,858	773	5.4	5.5	5.5
Mango	18,138	3,709	567	4.0	4.2	4.0
Pineapple	821	173	24	0.2	0.2	0.2
Papaya	2,158	481	64	0.5	0.5	0.5
Other tropical fruit	2,561	494	81	0.6	0.6	0.6
Other temperate fruit	9,077	1,680	302	2.0	1.9	2.1
Cultivated Forage Crops	4,158	934	124	0.9	1.1	0.9
Livestock						
Dairy (milk)	45,698	8,653	1,515	10.1	9.9	10.8
Cattle (meat)	9,735	1,213	376	2.2	1.4	2.7
Small ruminants (meat,milk, wool)	22,835	3,327	527	5.1	3.8	3.8
Poultry (meat & eggs)	19,880	3,568	653	4.4	4.1	4.7
Pigs	797	174	24	0.2	0.2	0.2
Aquaculture - Freshwater fish						
Carp	8,264	1,677	248	1.8	1.9	1.8
Tilapia	462	64	13	0.1	0.1	0.1
Misc freshwater fish	3,515	708	103	0.8	0.8	0.7
Cereal Grains	140,036	26,976	4,345	31.0	30.8	31.0
Roots, Tubers & Bananas	29,558	6,073	897	6.5	6.9	6.4
Oilseeds & Pulses	27,959	6,154	843	6.2	7.0	6.0
Smallholder Cash Crops	24,040	4,465	795	5.3	5.1	5.7
Vegetables & Melons	61,766	13,106	1,884	13.7	15.0	13.4
Tree Fruits	57,113	11,395	1,811	12.6	13.0	12.9
Livestock	98,946	16,935	3,095	21.9	19.3	22.1
Fish	12,240	2,449	363	2.7	2.8	2.6
ALL CROPS (x plantation)	340,472	68,169	10,575	75.4	77.9	75.4
ALL LIVESTOCK & FISH	111,186	19,384	3,458	24.6	22.1	24.6
ALL AGRICULTURE (x plantation)	451,658	87,553	14,033	100.0	100.0	100.0
Poverty = value weighted by $1.9/capita/day poverty headcount; stunting = value weighted by prevalence of child stunting.						
Value of forage crops included in value of livestock production.						

Latin America and the Caribbean (LAC)



Summary of findings from IPCC reports

- Decreased food production and quality (medium confidence)
- Spread of vector-borne diseases in altitude and latitude (high confidence)
- Increased migration in Central America due to extreme events and natural disasters (high confidence)

Top 5 climate hazards

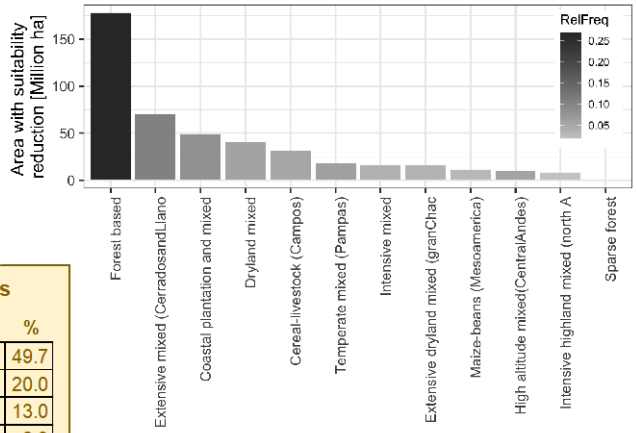
1. High temperature (117b US)
2. Flood (103b US)
3. Growing season reductions (37.8b US)
4. Drought (22.9b US)
5. Climate variability (14.2b US)

Modelled climate change impacts

31.2% less climatically suitable cropland

-5% wheat yield reduction

-25% maize yield reduction



Digital readiness

54% area with 2G, 3G or 4G network coverage

36% area with 3G or 4G network coverage

59% hazard exposed area suitable for climate information services

Greenhouse gas emissions

2,796
Tg CO_2 eq / yr
Total

Source	%
Deforestation	49.7
Livestock	20.0
Harvest	13.0
Crop	8.3
Fire	6.9
Rice	2.0

LAC Values and Value Shares of Commodity Production (average annual gross value of production 2017-2019)						
Commodity	Latin America & Caribbean (LAC) [excluding Brazil & Southern Cone]					
	Value (million 2015 I$)			Value Share (%)		
	Total	Poverty	Stunting	Total	Poverty	Stunting
Cereal Grains						
Rice	5,028	238	60	3.1	3.1	3.2
Wheat	869	17	8	0.5	0.2	0.4
Maize	7,849	243	98	4.8	3.2	5.2
Millet	0	0	0	0.0	0.0	0.0
Sorghum	433	16	5	0.3	0.2	0.3
Barley	248	5	2	0.2	0.1	0.1
Roots, Tubers & Bananas						
Potato	3,279	121	42	2.0	1.6	2.2
Cassava	733	40	8	0.4	0.5	0.4
Yam	252	19	3	0.2	0.3	0.2
Sweet Potato	244	10	2	0.1	0.1	0.1
Taro (cocoyam)	5	0	2	0.0	0.0	0.1
Banana	7,870	376	170	4.8	5.0	9.0
Plantain	3,436	148	45	2.1	2.0	2.4
Oilseeds & Pulses						
Groundnut	296	12	5	0.2	0.2	0.3
Soybean	1,300	56	21	0.8	0.7	1.1
Sesame	165	10	4	0.1	0.1	0.2
Beans (*phaseolus*)	1,850	87	30	1.1	1.1	1.6
Chickpea (*cicer*)	174	3	2	0.1	0.0	0.1
Cowpea (*vigna unguiculata*)	17	3	0	0.0	0.0	0.0
Pigeonpea (*cajanus*)	58	9	1	0.0	0.1	0.1
Lentil (*lens*)	11	0	0	0.0	0.0	0.0
Smallholder Cash Crops						
Cotton	1,124	25	11	0.7	0.3	0.6
Coffee	5,218	353	88	3.2	4.6	4.7
Coconut	433	14	4	0.3	0.2	0.2
Cocoa	967	37	15	0.6	0.5	0.8
Cashew	12	1	0	0.0	0.0	0.0
Vegetables & Melons						
Solanum (tomato, eggplant)	3,412	91	37	2.1	1.2	2.0
Allum (onion, shallot, garlic, leek)	1,792	60	21	1.1	0.8	1.1
Cucurbit (cucumber, pumpkin, melon)	1,800	71	25	1.1	0.9	1.3
Brassica (cabbage, cauliflower, broccoli)	472	19	7	0.3	0.3	0.4
Okra	64	3	1	0.0	0.0	0.0
Legume vegetables (green beans, peas)	211	8	4	0.1	0.1	0.2
Leafy vegetables (lettuce, spinach)	778	31	8	0.5	0.4	0.4
Vegetable, other	4,247	121	45	2.6	1.6	2.4
Tree Fruits						
Citrus (oranges, tangerines, lemons, other)	12,742	436	137	7.8	5.7	7.3
Mango	2,880	137	34	1.8	1.8	1.8
Pineapple	3,098	95	30	1.9	1.2	1.6
Papaya	1,068	24	10	0.7	0.3	0.6
Other tropical fruit	1,942	68	21	1.2	0.9	1.1
Other temperate fruit	2,413	76	27	1.5	1.0	1.4
Cultivated Forage Crops	12,838	386	156	7.8	5.1	8.3
Livestock						
Dairy (milk)	19,005	708	204	11.6	9.3	10.9
Cattle (meat)	19,941	789	253	12.2	10.4	13.4
Small ruminants (meat,milk, wool)	14,068	1,977	18	8.6	26.0	1.0
Poultry (meat & eggs)	25,317	842	299	15.5	11.1	15.9
Pigs	6,171	181	69	3.8	2.4	3.7
Aquaculture - Freshwater fish						
Carp	28	0	0	0.0	0.0	0.0
Tilapia	294	16	4	0.2	0.2	0.2
Misc freshwater fish	68	2	1	0.0	0.0	0.0
Cereal Grains	14,428	518	173	8.8	6.8	9.2
Roots, Tubers & Bananas	15,820	714	272	9.7	9.4	14.5
Oilseeds & Pulses	3,872	179	63	2.4	2.4	3.3
Smallholder Cash Crops	7,754	428	119	4.7	5.6	6.3
Vegetables & Melons	12,775	403	148	7.8	5.3	7.8
Tree Fruits	24,143	835	259	14.8	11.0	13.8
Livestock	84,501	4,496	843	51.6	59.2	44.8
Fish	390	18	5	0.2	0.2	0.3
ALL CROPS (x plantation)	78,792	3,078	1,034	48.1	40.5	54.9
ALL LIVESTOCK & FISH	84,892	4,514	848	51.9	59.5	45.1
ALL AGRICULTURE (x plantation)	163,683	7,592	1,882	100.0	100.0	100.0
Poverty = value weighted by $1.9/capita/day poverty headcount; stunting = value weighted by prevalence of child stunting.						
Value of forage crops included in value of livestock production.						

Section 4: The Two Degree Initiative Regional Challenges vis-à-vis Emerging Priorities

The 'Two Degree Initiative' (2DI) formed as a coalition of hundreds of like-minded partner organizations from around the world, brought together with a single unifying vision – to transform the global food system for a climate-smart future. 2DI's ambition is to reach 200 million farmers in ten participating Regional Challenges that include low- and middle-income countries. It organizes its projects around a set of six emerging themes that align with a rigorous theory of change.

Over a thousand stakeholders were consulted through more than 50 meetings (Listening Sessions) held between May – October 2020. These were led by CCAFS and the World Resources Institute (WRI), which co-manages the Global Commission on Adaptation and is a leading partner in the 2DI coalition. The goal of the Listening Sessions was to develop a common vision of climate resilient agriculture and food systems for each of ten participating Regional Challenges.

The sessions (held virtually because of the COVID-19 situation) resulted in a roadmap of actions and partnerships required to achieve the common vision of each region. In addition, they helped to identify (preliminarily at least) global topics for rigorous Research for Development (R4D) programs to be led by the CGIAR and its regional partners, all of which are locally-informed and designed to lead to transformational change on the ground.

These listening sessions provide an interesting starting point for considering climate-leading Regional Integrated Initiatives for CGIAR. Six emerging findings came from the listening sessions which are of relevance for the design process of Regional Initiatives:

1. Forging a new partnership model for CGIAR, where CGIAR is a key knowledge partner in coalitions of change agents, led by change agents
2. Research and action on sustainable finance for small-scale agricultural producers, bringing in USD 100s of millions to foster climate action, implying a strong private sector focus
3. Research and action to empower small-scale agricultural producers, women, youth and marginalized communities as groups that are most vulnerable to climate change
4. Climate-informed digital advisories, services and decision support to ensure that small-scale agricultural producers and their service providers and value chain actors are getting the appropriate information and services to manage risks, grow farmer incomes and expand employment opportunities
5. Attention to research and action on policy and institutional reforms, as the policy and institutional context is crucial to achieve scale and transformation
6. Mainstreaming low emissions value chains, including attention to the necessary changes in consumption and food loss and waste (while much of the work will be on adaptation, the intention is to put development on a low emissions pathway)

In the below analysis, four criteria were used to assess the goodness of fit for the 2DI regional challenges to form a basis for developing One CGIAR Regional Integrated Initiatives. Two initiatives emerge as being highly relevant as the starting point for the Design Process (Asian Mega Deltas and Southern Africa Drylands) having been developed with considerable stakeholder consultation, and being a close match to CGIAR strategy and the analysis of climate hazards. Two LAC regional challenges exist, and some combination of these two would also form the basis for a solid Regional Integrated Initiative which

responds to demands from the region, aligns to CGIAR strategy and matches the evidence of the principal challenges.

Table 1: Criteria for 2DI regional challenges prioritization

2DI Regional Challenge	Region in OneCGIAR	Stakeholder engagement[1]	Consistency with OneCGIAR approach[2]	Alignment with major risks in relation to vulnerability and mitigation potential	Consolidated assessment
Southern African Drylands: Climate resilient and Water-Secure Livelihoods	ESA	H	H	H	H
Latin America: Transitioning to Low-Emissions Sustainable Meat and Dairy Production Landscapes	LAC	M	M	M	M
Securing the Asian Mega-Deltas against Sea-Level Rise, Flooding, and Salinization	SEA, SA	H	H	H	H
Building Food System Resilience to Climate Shocks in the Sahel	WCA	M	M	M	M
Resilient Households in Central and Tropical Andes and Central America	LAC	H	H	M	H
Horn of Africa	ESA	L	M	M	M
MENA Grand Challenge	CWANA	M	H	M	M
West Africa: One-Health	WCA	M	M	L	M
Blue Challenge: Resilient Fisheries and Aquaculture	SA, SEA, ESA	M	M	M	M

H=high; M=medium; L=low

Table 2: Alignment of 2 Degrees Initiative Regional Challenges to One CGIAR ways of working

2DI Regional Challenge	Systems Transformation	Strategic Alliances	Multiple Pathways	Risk and Resilience	Innovative Finance	Digital Revolution	Final
Southern African Drylands: Climate resilient and Water-Secure Livelihoods	H	H	H	M	H	H	H
Latin America: Transitioning to Low-Emissions Sustainable Meat and Dairy Production Landscapes	M	H	M	M	H	L	M
Securing the Asian Mega-Deltas against Sea-Level Rise, Flooding, and Salinization	H	H	M	H	H	H	H
Building Food System Resilience to Climate Shocks in the Sahel	M	H	L	M	L	H	M
Resilient Households in Central and Tropical Andes and Central America	H	H	M	H	H	H	H
Horn of Africa	H	M	M	M	H	L	M
MENA Grand Challenge	H	H	L	M	H	H	H
West Africa: One-Health	H	H	L	H	L	M	H
Blue Challenge: Resilient Fisheries and Aquaculture	M	M	L	M	H	L	M

H=high; M=medium; L=low

Table 3: Alignment of 2 Degrees Initiative Regional Challenges to One CGIAR impact areas

2DI Regional Challenge	Nutrition, Health and Food Security	Poverty Reduction, Livelihoods and Jobs	Gender Equality, Youth and Social Inclusion	Climate Adaptation and Mitigation	Environmental Health and Biodiversity	Final
Southern African Drylands: Climate resilient and Water-Secure Livelihoods	L	H	H	H	M	H
Latin America: Transitioning to Low-Emissions Sustainable Meat and Dairy Production Landscapes	M	M	L	M	H	M
Securing the Asian Mega-Deltas against Sea-Level Rise, Flooding, and Salinization	M	M	H	H	M	M
Building Food System Resilience to Climate Shocks in the Sahel	H	M	H	M	M	M
Resilient Households in Central and Tropical Andes and Central America	H	H	H	H	H	H
Horn of Africa	H	M	H	M	H	H
MENA Grand Challenge	H	M	H	H	L	H
West Africa: One-Health	H	M	M	M	M	M
Blue Challenge: Resilient Fisheries and Aquaculture	M	M	H	H	M	M

H=high; M=medium; L=low

Section 5: Proposed priority setting process during Initiative Design

Integrated programs should follow fundamental steps as they move from strategic planning to tactical implementation[3]:

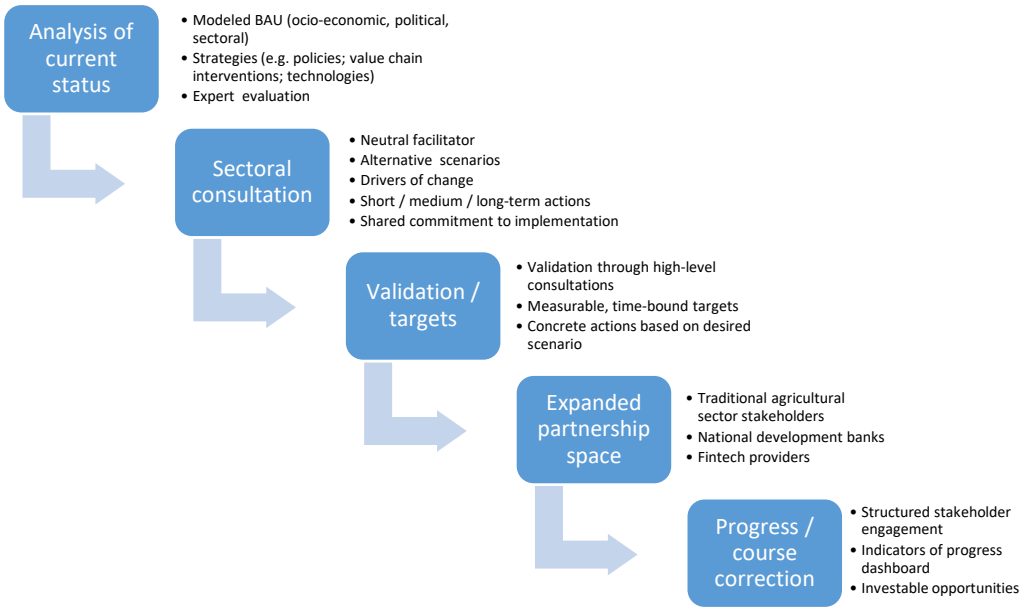
- Strategic multi-stakeholder planning process
- Tactical plan development based on the integration of production and demand (private sector and public purchasing), where appropriate taking a mixed menu-approach based on and connected with the global and regional science domains.
- Implementation of multi-stakeholder innovation hubs for the generation of impact and that serve as on the ground real life 'experiments'
- Feedback loop of data and information to the science domains

Integrated regional programs are governed by multi-stakeholder arrangement and are designed to engage diverse partners and to undertake:

- Baseline assessments (e.g., agricultural value chains; household dietary patterns; gender norms; local markets and institutions) and gap analysis for the ability of local agri-food systems to deliver sustainable livelihoods and health diets;
- Business-as-usual and preferred production-consumption scenarios;
- Regional risk and opportunity assessment with robust, well-structured stakeholder engagement;
- Evaluation of potential pathways (including value chain and public policy interventions);
- Selection and testing of household, farm, landscape and value chain strategies to ensure diversified nutrition and income;
- Applied research and innovation
- Big data generation
- Review and communication of results, development and refinement of innovation models / prototypes;
- Policy engagement (e.g. through inter-ministerial platforms).
- Training of NARS scientists (especially women and other underrepresented groups) and value chain actors (farmers, public / private sector farmer advisors)

[3] Methodology based on:

1. Bram Govaerts, Christine Negra, Tania Carolina Camacho Villa, Xiomara Chavez Suarez, Anabell Diaz Espinosa, Simon Fonteyne, Andrea Gardeazabal, Gabriela Gonzalez, Ravi Gopal Singh, Molly Jahn, Victor Kommerell, Wietske Kropff, Victor Lopez Saavedra, Georgina Mena Lopez, Sylvanus Odjo, Natalia Palacios Rojas, Julian Ramirez-Villegas, Jelle Van Loon, Daniela Vega, Nele Verhulst, Lennart Woltering, Martin Kropff. 2021. The Integrated Agri-food Systems Initiative: from short-termism to transformation within the OneCGIAR and beyond?! Under revision.
2. Gardeazabal, A., Lunt, T., Jahn, M.M., Verhulst, N., Hellin, J., Govaerts, B., 2021. Knowledge management for innovation in agri-food systems: a conceptual framework. Knowledge Management Research & Practice, DOI: 10.1080/14778238.2021.1884010



Past examples demonstrate that the integrated regional approach can deliver impact at scale. Common success factors have been noted:

- A deliberate mix of technological, institutional, and socio-economic analysis
- Sufficient time for multi-objective demand mapping undertaken by a multi-disciplinary team;
- An inclusive, iterative consultative process with all prospective innovation and scaling partners resulting in a robust theory of change and concrete commitments and co-investments by partners for an agreed research program;
- Multiple R4D and scaling pathways and impacts (e.g. capacity building; policy; value chains);
- Program and budget continuity to sustain productive innovation and scaling partnerships and influence enabling institutions;
- Well-resourced, professionally-staffed support functions that reduce management complexity (e.g. knowledge management, M&E, communications).

Future enhancements can include:

- More deeply engaging women and men in place-based, collaborative improvement of their agricultural productivity, income, nutrition, equity, and agency including multi-scale interactions.
- Developing additional integrative skillsets and trans-disciplinary competencies.
- Eliciting nutrition-sensitive agrifood innovation that meaningfully increases food-related income, diversifies local markets and diets, and builds resilience into agricultural value chains.
- Monitoring performance of long-term organizational partnerships that deliver regional integrated programs.

Integrated programs – methodology for operation

Knowledge is a critical enabling factor for healthy agri-food innovation systems (AIS). AIS and related knowledge management frameworks face significant implementation challenges. The proposed

framework addresses systemic interactions favouring innovation outcomes by formalizing flows and management of information and knowledge between diverse sets of stakeholders; and explicitly considering previously unresolved practical and relational barriers aiming to facilitate more equitable, rapidly evolving, and actionable knowledge generation and management for innovation and transformational change. Figure 7 represents the primary processes within the proposed framework, integrating the eight principles with key concepts required to facilitate innovation in agri-food systems. The process elements of the framework are explained below.

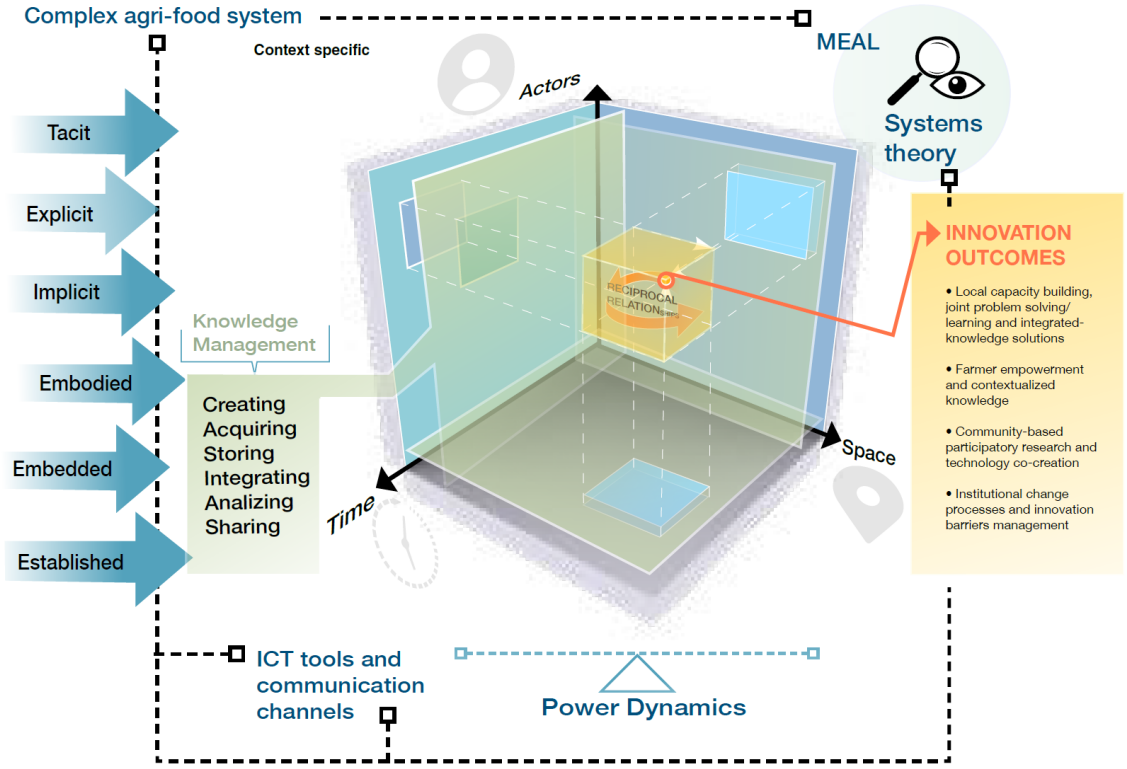


Figure 7 – Proposed operational framework to facilitate innovation in agri-food systems

The innovation work is organized in distinct hubs (Fig. 8); each hub has a physical infrastructure, including research platforms, modules, extension and impact areas, which are used for networking, knowledge exchange and co-creation. In the research platforms, local partners evaluate technologies resulting from the global initiatives and local tacit knowledge to develop research-based recommendations for farmers. In modules, farmers are connected to peers, farm advisors and other value chain actors. Together they implement and adapt best practices from research platforms and compare them with conventional practices. Extension areas are agricultural fields where farmers test new technologies in connection with modules or research platforms, whereas in impact areas farmers have adapted and adopted similar knowledge, technologies and innovations on their own.

This infrastructure is used to build a network of stakeholders – farmers, farm advisors, scientists, research centres, private initiative, and government actors, among others – that collaborate around a common objective: innovation in the agri-food system to make it more sustainable, productive, profitable and resilient. The hub model considers farmers important change agents and central to the approach. Since inception, hubs have been allowed to evolve independently in order to match their

divergent agricultural, stakeholder, and technological contexts, and to reflect the landscape of relationships between different actors in the agri-food system (Camacho-Villa et al., 2016).

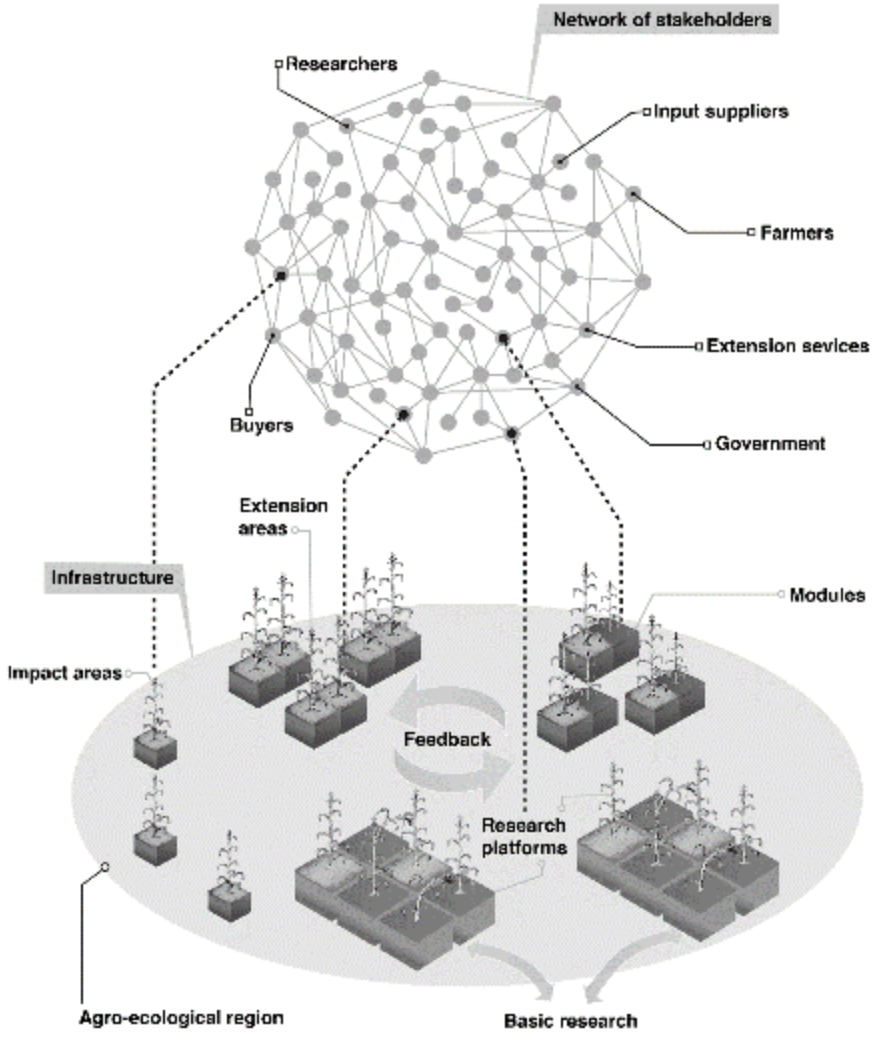


Figure 8 – Operational innovation network of an integrated agri-food system initiative

Integrated programs – Way forward

Existing regional integrated programs span multiple science domains:

- Policy, value chains and markets
- Nutrition and one health
- Sustainable agricultural production systems
- Land, soil and water systems
- Genetic resources and breeding

With support from ABC, CIMMYT has tested and implemented a methodology to develop the

- Strategic planning based on scenarios for a better future
- Tactical planning
- Operational methodologies for implementation

Section 6: Conclusions and proposed ways forward

Region	Potential way forward based on analysis
CWANA	Develop a Regional Integrated Initiative with a strong focus on drought and climate variability as the primary climate hazards affecting the region.
WCA	Consider am initial focus on, or on root and tuber crop, forest-based, and cereal-root-crop mixed systems in more humid southern regions of WA. Further disaggregated analysis of climate hazards for humid regions should help further prioritise, but initially consider growing season high temperatures, and growing season length reductions as key climate hazards for focus. Another RII for WCA may concentrate on agro-pastoral dry systems in the Sahel as an additional priority within the region.
ESA	Design a Regional Initiative which builds off of the Two Degree Initiative on southern African drylands, considering the geographic priorities to potentially extend to high hazard regions in East Africa, and/or paying special attention to maize mixed systems and pastoral systems.
Asia (SEA + SA)	Develop a regional integrated initiative which builds off of the 2DI regional challenge on mega deltas, focusing on flooding and salinization as the primary climate hazards. Consider the extent to which mixed upland intensive systems are relevant, given the significant area impacted by climate stemming from this analysis.
LAC	Develop Regional Integrated Initiative building off of the 2DI regional challenge on building household resilience that addresses both subsistence and commercial farming through innovations that equip farmers with better on-farm technologies, information, and access to finance. Bring in an additional component integrating mitigation action also into the initiative given the significant share of emissions coming from Latin America. The latter should likely explore land-use change at the forest-agriculture frontier, as well as livestock-based farming systems. This can potentially come from the other 2DI regional challenge on meat and dairy in LAC. Forest-based and extensive-mixed farming systems should be considered in the design process.

Annex 1 – Methods

Figure 1: The base layer for analysis of climate hazards was developed by Phil Thornton (unpublished), which uses three indicators for current climate hazards:

- Areas where the coefficient of variation of annual rainfall (the standard deviation divided by the mean, expressed as a percentage) is currently greater than the median value for the global tropics (24%). In lower latitudes, climate change is projected to increase this variability, making both cropping and rangeland production more risky. Because we have little information on the nature of this variability change, we used current variability as a proxy for future variability.
- For relative flood risk, grid cells in the top two deciles (most risky) of the data set of Dilley et al. (2005) were defined as high-risk flooding areas.
- For relative drought risk, grid cells in the top two deciles (most risky) of the data set of Dilley et al. (2005) were defined as high-risk drought areas.

For future climate hazards, we used downscaled climate projections from 17 CMIP5 global climate models using the methods in Jones and Thornton (2009; 2013; 2015) and climatologies for the 2050s as projected in response to RCP 8.5. Two climate hazard thresholds were defined in relation to climate and how changes to the 2050s might affect different facets of agriculture and food security:

- Reduction in the number of reliable crop growing days per year below 90, a critical threshold (Nachtergaele et al., 2002), mostly due to changes in rainfall distributions and amounts;
- Areas in which the average maximum daily temperature during the primary growing season moves above 30 ^{o}C by the 2050s, a critical threshold for several major crops (Boote et al., 1998; Prasad et al., 2008).
- The intersection of the various climate hazards, exposure and vulnerability data layers were analysed with respect to their areas, agricultural land use (i.e., whether crop land, pastureland, or land with both crops and pasture present), and human population. We used estimates of human population for the year 2020 from CIESIN (2018).

The resultant map is shown below in Figure 1.

Figure 2: These hazards in Figure 1 were then overlaid with datasets from the Digital Atlas of Adaptation on Value of Production for both crops and for livestock, and for rural population. The value of production was calculated based on spatial layers of crop distribution, and economic data on productivity and prices. The dataset is disaggregated for livestock and for crops. Furthermore, rural population was also calculated for each region, and overlaid with the hazards.

Figure 3: Emissions data was taken from Roman-Cuestra et al. (2016)[4], reporting for each region the gross emissions (Figure 3a) and the relative source of emissions from different sources, including deforestation, fire, wood harvest, livestock, rice, and crop (essentially representing soil based emissions, e.g. fertilizer use, soil management) (Figure 3b). Unfortunately, in this dataset the data is not available

[4] Rosa Maria Roman-Cuesta, Mariana C Rufino, Martin Herold, Klaus Butterbach-Bahl, Todd S Rosenstock, Mario Herrero, Stephen Ogle, Changsheng Li, Benjamin Poulter, Louis Verchot, Christopher Martius, John Stuiver, Sytze De Bruin, 2016, Hotspots of gross emissions from the land use sector: patterns, uncertainties, and leading emission sources for the period 2000–2005 in the tropics, Biogeosciences. https://bg.copernicus.org/preprints/bg-2016-99/bg-2016-99-manuscript-version4.pdf

for CWANA, but can be calculated relatively easily and feed into the design process over the coming months.

Figure 4: This figure is derived from the Evidence for Resilient Agriculture (ERA) meta-data project.[5] ERA has screened, harmonized and extracted data from 2,000 journal articles that describe the impacts of changing agronomic, agroforestry or livestock technologies on more than 75 indicators of productivity, resilience or emission. ERA uses meta-analysis to synthesize results across studies providing general conclusions on what works where.

Figure 5: This figure represents data from the largest meta-analysis of adoption literature. It includes information derived from 168 separate studies analyzing the same management practices included in ERA. The analysis uses a quantitative sign-test to evaluate the likelihood of a statistically significant association in the dataset. Preliminary results can be found in Arslan et al.[6]

[5] http://era.ccafs.cgiar.org

[6] https://www.ifad.org/en/web/knowledge/publication/asset/42041675