Data and evidence-driven assessment of priorities for the Livestock, Climate and System Resilience (LCSR) One CGIAR global initiative

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Contents

1. Synthesis of initiative priorities

Based on the evidence presented for each of the challenges (section 4), the capacity of the CGIAR to deliver outcomes for livestock agrifood systems (LAFS) across the five impact areas, and the interest and engagement of national and regional stakeholders regarding the Livestock, Climate and System Resilience (LCSR) initiative (section 5), various geographic priorities emerge (table 1). In all these contexts, the focus will be on mixed systems as well as pastoral rangelands. The geographic focus across work packages is kept as consistent as possible to maximize synergies and interactions between them.

Table 1 Geographic focus per work package for the LCSR initiative

Region	Priorities
ESA	– 2022-2024: Kenya, Ethiopia, Tanzania, focusing on scaling and south-south exchange – post 2024: Uganda, South Sudan, Mozambique, Zimbabwe, Malawi
WCA	– 2022-2024: Senegal (scaling, breaking new ground), Mali (breaking new ground) – post 2024: Nigeria, Burkina Faso, Niger, Ghana
LAC	– 2022-2024: Colombia (scaling, south-south learning), Guatemala (breaking new ground) – post 2024: Honduras, El Salvador, Peru, Ecuador, Brazil
SA	– 2022-2024: None – post 2024: India, leveraging OneHealth work to implement LCSR research agenda
SEA	– 2022-2024: None – post 2024: Vietnam, Philippines, Indonesia
CWANA	– 2022-2024: Tunisia (scaling, and south-south) – post 2024: Kyrgyzstan, Sudan, Tajikistan

We recognize that climate adaptation and mitigation for the livestock sector should be a priority in many countries, and that the list of countries proposed for the 2022-2024 cycle is relatively small compared to the identified needs (section 4) and stakeholder demand (section 5). We thus propose a phased approach. In Kenya, Tunisia, and Colombia we are building upon years of research and stakeholder engagement under previous CRPs (Livestock and CCAFS) as well as bilaterally funded projects. This work has produced innovations ready to go to scale as well as policy influence. Work on these countries will focus on (i) South-South exchange of innovations into other countries and regions, (ii) filling specific R4D gaps that still exist in LAFS adaptation, resilience, and mitigation; and (iii) testing specific innovations that are applicable across most or all other countries. Efforts in countries such as Mali or Senegal where past CGIAR investment has been comparatively lower will focus on the full spectrum of LCSR interventions. In addition, the prioritization work below points to a broader geographic range of countries that LCSR currently has resources to accommodate. Thus, we have not selected any part of South Asia or Central Asia. It is our hope that the second (2025-2027) and third (2028-2030) phases of LCSR will allow working in those regions.

The priorities presented in table 1 also seek to capitalize on potential and planned synergies with other initiatives (see table 2).

Table 2 Geographic and topical synergies with other One CGIAR initiatives

Initiative	Countries and geographic synergies	Topical synergies
ClimBer	Guatemala, Kenya, Senegal, Philippines, Morocco, Zambia	– Climate services and insurance design – Climate security observatory and programmatic recommendations
SAPLING	Kenya, Tanzania, Ethiopia, Mali, ~~Nepal, Vietnam~~	– Technologies, practices for sustainable production – Equity and social inclusion – Digital tools for markets and value chains – Trade-off analysis and policies that account for social, environmental, and economic outcomes
U2 (ESA RII)	Ethiopia, Kenya, Tanzania, ~~Zambia~~	– Scaling hubs – Sustainable intensification – De-risking mixed systems through advisory services, and early warning – Empower and engage women and youth – Ag-Tech partnerships and incubators
LACResiliente (LAC RII)	Guatemala, Honduras, Colombia Mexico, Peru	– Climate risk management services, ICT development, and data hubs – Scaling platforms (InnovaHubs)
Data Harnessing	Guatemala, Kenya, Ghana, Mozambique, Rwanda, Egypt India, Bangladesh, Vietnam, Philippines	– Data hubs, ICT development, advisory services, and modelling methods and infrastructure – Ag-Tech partnerships, – Digital inclusion approaches
OneHealth	Kenya, Ethiopia, Uganda, India, Vietnam, Ivory Coast	– Surveillance and modeling of zoonoses – Development of advisory services for livestock health management and early warning – Capacity building for partners and producers
Mitigate+	Kenya, Ethiopia, Colombia	– Financing and technologies for emissions reductions in value chains
Genebank (GBI)	Global	– Rangeland biodiversity conservation – Guarantee availability of diversity – Increase value and use of collections

2. Analytical framework

Livestock are the source of food and livelihoods for billions of people. Yet livestock agrifood systems (LAFS) are facing enormous exposure to and pressure from climate change, climate variability and extremes, while at the same time contributing substantially to global greenhouse gas emissions (GHGe). The livestock sector urgently needs to reduce its environmental footprint and livestock systems need to become more climate resilient. The LCSR One CGIAR initiative aims at building the adaptive capacity and resilience of LAFS to climate-related shocks and stresses and reducing their impact on the climate system. This report outlines the topical, systems and geographic focus of the Initiative.

The prioritization approach implemented followed three major steps:

1. Review of the literature and previous stakeholder engagements to identify key climate-related adaptation/mitigation and systemic resilience challenges for LAFS
2. Data analysis and evidence synthesis using secondary data and existing literature, per each identified challenge, to target geographical and/or value chain focus
3. Qualitative multi-criteria assessment of the data driven priorities identified in Step 2 to define short-list of priority countries and activities

3. Challenge identification

Research on livestock and climate change is relatively sparse in comparison to crops (Campbell et al., 2016). In the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, the number of crop-related climate impacts and adaptation studies examined is roughly 500% greater compared to livestock-related studies. To identify the key challenges affecting livestock production, we took stock from a recent global review of adaptation and mitigation options for the livestock sector of Rivera-Ferre et al. (2016), and the review of adaptation challenges for livestock of Godde et al. (2021). Additional insight was derived as needed from studies cited therein, including Thornton et al. (2009) who synthesize climate impacts research for livestock; Thornton and Herrero (2010) and Xu et al. (2021) who analyze global methane and carbon dioxide emissions; and Thornton and Herrero (2014, 2015) who discuss climate adaptation options for mixed crop-livestock systems. Likewise, Herrero et al. (2016) highlight that the impacts of climate change on the rangelands of the globe and on the vulnerability of the people who inhabit them will be severe and diverse, and will require multiple, simultaneous responses.

We synthesized the challenges outlined by these studies into seven statements applicable globally and regionally. It is noteworthy that given the global disparity in terms of population, value of production, and surface area between mixed systems and rangelands, and the recognition that both systems are important for CGIAR, challenges are designed to capture joint as well as individual challenges in both types of systems.

1. Livestock producer livelihoods and livestock production are threatened by short and long-term rainfall and temperature variations and their changing predictability.
2. Climate information systems do not reach many livestock producers, particularly those in remote areas. Hence, they lack literacy on climate prediction for risk management. Climate information systems also fail to effectively package their information for uptake and use.
3. Culturally embedded social norms and practices often limit or altogether marginalize women, youth or other vulnerable groups from benefitting from livestock. Specifically, women and youth’s limited ability to own, control and benefit from livestock often constrain their potential to benefit from resilient, low emissions (RLE) livestock strategies. This is true at all scales, from household production through to value chains, and in institutions and policy.
4. Livestock are responsible for a significant proportion of national and global GHGe. These are from direct enteric emissions, manure and soil emissions, land conversion and production inefficiencies.
5. Public and private investors including climate finance are reluctant to invest in livestock production due to a generalized negative perception of livestock due to potential harms to the environment (e.g., deforestation, GHG emission) and perceived financial risks (e.g., in pastoral systems). In addition, reliable monitoring systems are not in place to monitor, verify and report nature-positive impacts realized by the investments.

6. Rangelands are under severe and diverse stress from climate change, degradation, and deterioration, yet there is a significant gap in investment in rangeland restoration and improvement.
7. Development and climate change policies pertaining to LAFS are not well coordinated and lack coherence. The former fail to account for either climate adaptation or mitigation targets. The latter are not always cognizant of development targets or strategies.

The next step was to identify geographic and system priorities for those challenges that lend themselves to this type of analysis. For some of the challenges, such an analysis was not relevant to the priority setting, and thus prioritization relied on literature, key strategy documents, and discussions with stakeholders such as national decision makers and investors.

4. Geographic and systems priorities per challenge

The prioritization process presented in this document aims at identifying geographies (countries and production systems) where the challenges outlined above (see Sect. 3) are most prominent. We review the literature and analyze existing data within all countries in CGIAR regions, namely, East and Southern Africa (ESA), West and Central Africa (WCA), Latin America and the Caribbean (LAC), South Asia (SA) and South-East Asia (SEA). Within all regions and countries, we analyze the relevance of existing livestock production systems with respect to all the challenges. For this, we use a relatively broad definition of livestock production systems (Robinson et al., 2011) (Fig. 1). In this definition, livestock production is divided into three types, namely, landless, rangeland, and mixed systems. Mixed systems are divided into rainfed and irrigated, which then gives rise to four broad system categories (i.e., landless, rangelands, mixed rainfed, mixed irrigated). Each of these categories is then divided into agro-ecologies (temperate, humid, arid, hyper-arid).

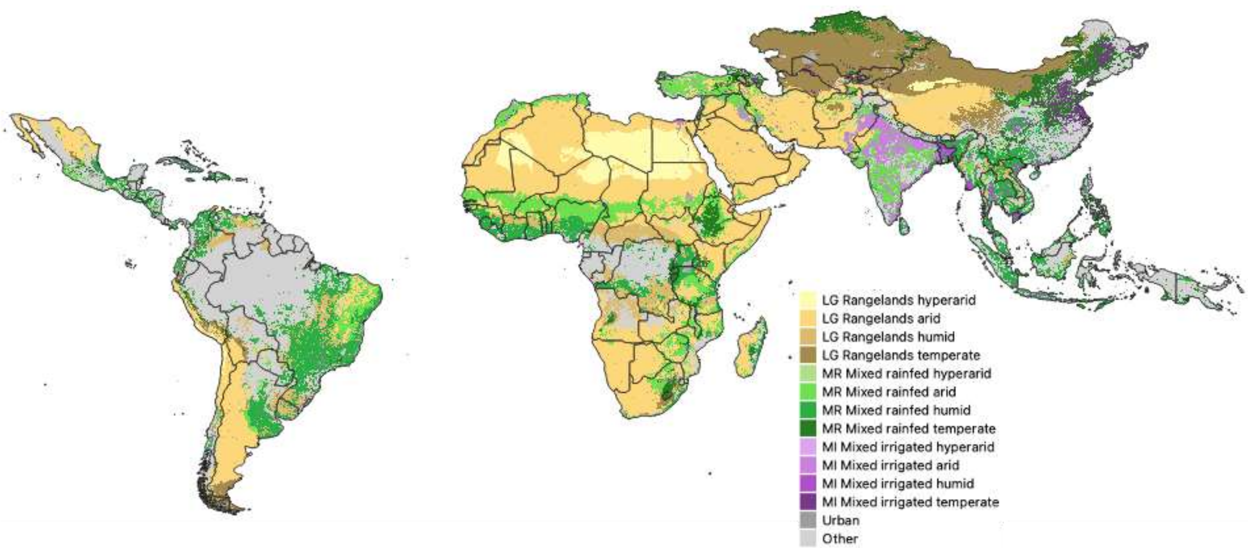

Figure 1 Global geographic distribution of livestock production systems based on Robinson et al. (2011) for all CGIAR regions.

4.1. Challenge 1: Livestock producer livelihoods and livestock production are threatened by short and long-term rainfall and temperature variations and their changing predictability

Rationale and existing knowledge gaps

Climate change, climate variability and extremes hinder livestock agri-food systems (AFS) directly through reductions in productivity and quality, precipitating pest/disease outbreaks and emergence, price shocks, and supply disruptions that affect producers and other value chain actors (Thornton and Herrero, 2015; Rojas-Downing et al., 2017). About 994 billion USD in livestock value (~55% of total) are exposed to various climate hazards, especially climate variability (198 billion USD) and heat stress (130 billion USD) (Jarvis et al., 2021). Recent model-based studies suggest that livestock production systems and value chains need adaptation for the coming decades. Rojas-Downing et al. (2017) present a comprehensive view of climate impacts on livestock that includes effects on water consumption, forage, reproduction, production, and health. Furthermore, Thornton et al. (2021) demonstrate the urgency of adapting livestock production to heat stress during the 21st century in many parts of the tropics, with particularly negative effects in mixed systems and rangelands in arid and semi-arid regions. Godde et al. (2020) estimate that 74% of global rangeland area is projected to experience a decline in mean biomass, 64% an increase in inter-annual variability, and 54% an increase in intra-annual variability by 2050. Rangeland systems especially in arid lands are experiencing intensifying impacts from climate change and other forces (Herrero et al., 2016; Cervigni and Morris, 2016). Land degradation, productivity losses, conflicts, food insecurity, and displacement of populations have resulted.

While adaptation to these impacts is an urgent need, the set of adaptation interventions that best addresses the combination of hazards, as well as reliable measurements of their effectiveness warrants further investigation. Most notably, as opposed to crop production (e.g., Challinor et al., 2014) model-based projections of adaptation benefits for livestock systems are scarce (but see Descheemaeker et al., 2018). Experimental work provides evidence about the effectiveness and adoption of climate adaptation practices and technologies (see e.g., Garcia de Jalon et al., 2017; Zougmouré et al., 2016), but more evidence on the potential of these practices alone and in combination, and their potential returns for mixed and pastoral rangeland systems is needed for scaling. Furthermore, the building of this evidence needs to go hand in hand with the building of capacities of local and regional organizations, the public sector, and producers to promote and implement adaptation options.

Priority setting approach and synthesis of results

To identify geographic priorities, we performed a geospatial data analysis that helped characterize livestock producer livelihoods and livestock production systems and identify threats related to short- and long-term variations in rainfall and temperature within them. The analysis involved two steps: (i) the mapping of hotspots that could experience climatic hazards (hazard classes hereafter) and the adaptive capacity within the livestock systems; and (ii) the assessment of exposure to these climatic hazards within each country and livestock systems in terms of rural population, value of production, tropical livestock units (TLU) and pasture area.

For (ii) ten hazard classes were identified using four dimensions, namely climate variability, heat stress, flood risk, and drought. To characterize climate variability, we used the coefficient of variation of annual mean rainfall (15–30% highly variable, >30% extremely variable), derived from the CHIRPS dataset (Funk et al., 2015). Areas of heat stress were defined as having thermal heat stress (ThI, projected for 2030 under an 8.5 RCP scenario), equal or higher than 79 units (see Thornton et al., 2021). To define areas with risk of flooding we used the UNEP-GRID dataset, in which flooding risk is ranked from 0 (no risk) to 5 (extreme) (UNEP/DEWA/GRID-Europe, 2011). Areas with risk of drought were defined as having more than 24 days without rain per month on average. We defined the adaptive capacity of livestock systems to these hazards using the 2018 poverty headcount ratio at US$1.9 per day (2011 PPP) as reported at the subnational level by the World Bank (World Bank, 2021) as a proxy. Three adaptive capacity categories were defined: low (>25%), medium (10-25%), and high (<10%). We analyze only areas with poverty rates above 10% and rainfall coefficient of variation above 15%, and within these, we analyze the remaining dimensions (heat stress, flood hazard risk, and drought). TLU values were computed following Rothman-Ostrow et al. (2020) using data from the Gridded Livestock of the World database (GLW version 3) (Gilbert et al., 2018); value of production data is from Thornton and Herrero (2010); and rural population data from WorldPop[1].

In areas considered with medium and low adaptation capacity (poverty rate > 10%) hazard combinations such as climate variability and heat stress (CV+ThI); climate variability, heat stress and flooding (CV+ThI+F); climate variability, heat stress and drought (CV+ThI+D); and all hazards together (CV+ThI+D+F) are all prevalent (Fig. 2). Their importance, however, varies across systems. Areas in the Sahel experience heat stress by 2030 and present high climate variability, heat stress and risk of drought. In East Africa, climate hazards are related to climate variability, heat stress, drought but also flood. In India, a large proportion of the area under mixed systems shows low adaptive capacity combined with all hazards (CV+ThI+D+F).

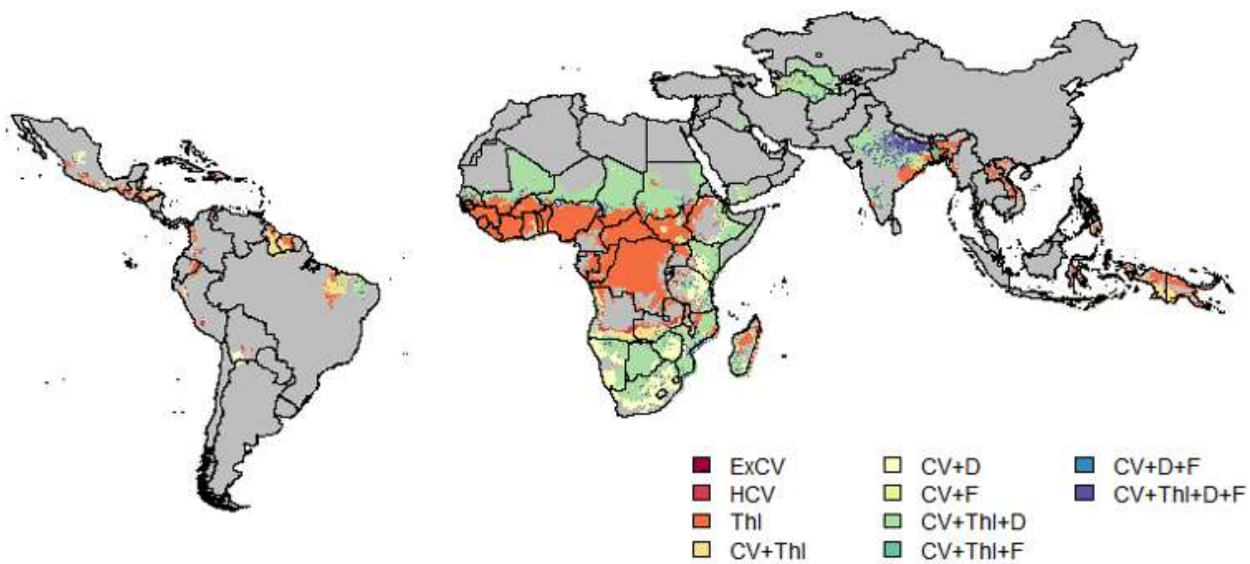

Figure 2 Potential climatic hazards in low and medium adaptive capacity within CGIAR regions. ExCV= Extremely high climate variability, HCV= High climate variability, CV= Extremely or High climate variability, ThI= Heat stress, D= Drought, F= Flooding.

The characterization of the hazards classes across livestock production systems within the CGIAR regions (Fig. 3) shows that mixed rainfed arid and humid regions have the largest number of people, production value, and tropical livestock units exposed to climate hazards. These systems are followed by rangelands arid systems and mixed irrigated arid systems, especially in terms of value of production and TLU. The types of hazards vary. Mixed rainfed humid systems are primarily exposed to heat stress, whereas mixed rainfed arid systems are exposed to drought and climate variability in addition to heat stress.

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

Arid rangelands show a similar picture to mixed rainfed arid systems, but with about half the amount of people, 70% of the production value, but almost the same amount of TLU.

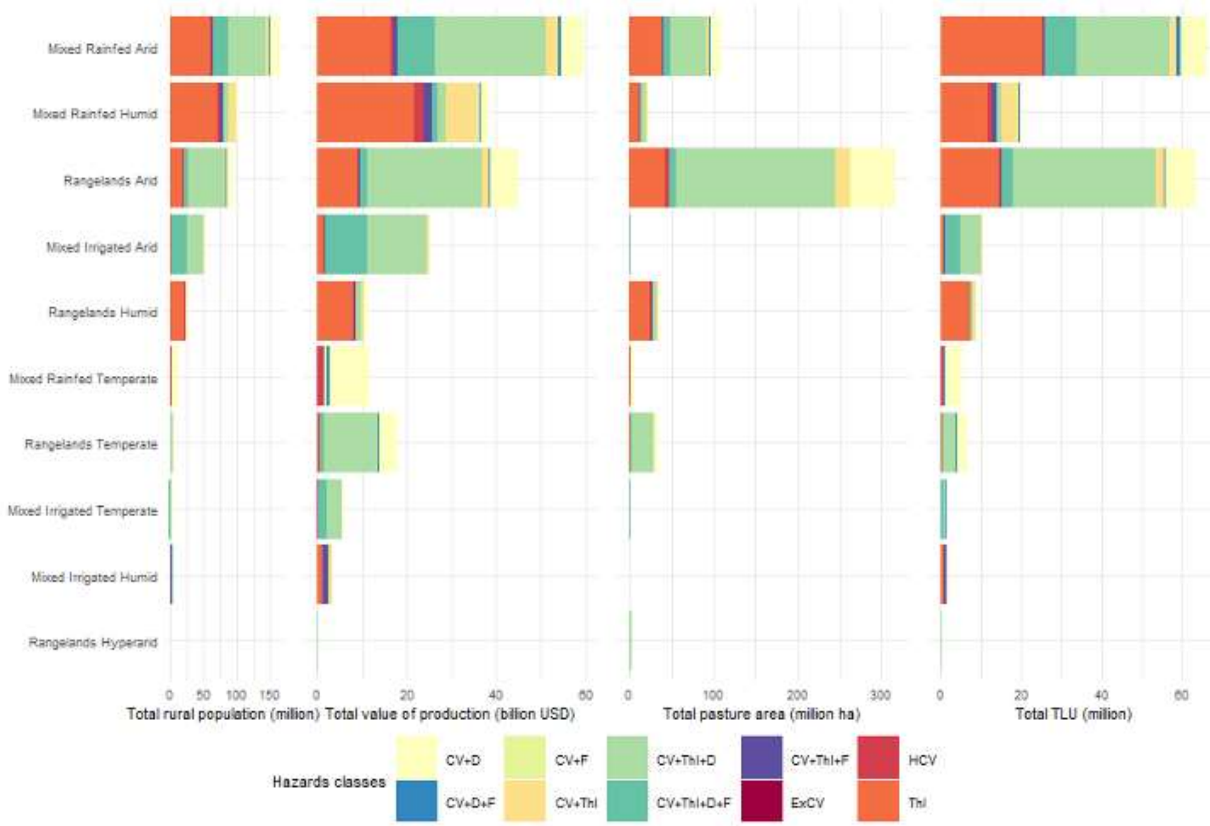

Figure 2 Hazard classes across and characterization of the livestock production systems in all CGIAR regions in terms of total rural population, total value of production, total pasture area, and tropical livestock. ExCV= Extremely high climate variability, HCV= High climate variability, CV= Extremely or High climate variability, ThI= Heat stress, D= Drought, F= Flooding.

The geographic priorities for adapting livestock production systems and value chains to climate change are relatively large in size, since as illustrated in Fig. 2, in mixed rainfed arid systems alone nearly 60 billion USD and 175 million people are exposed to climate hazards. These systems occur throughout substantial parts of ESA, WCA, and SA, and to a lesser extent LAC, SEA, and CWANA.

Based on the data obtained from the analyses, several potential priorities emerge (Table 3).

Table 3 Possible priority countries and systems for addressing Challenge 1

Region	Possible countries and systems based on priorities
East and Southern Africa (ESA)	– Ethiopia: Rangelands Arid (LGA), Mixed Rainfed Arid (MRA) – Kenya: Mixed Rainfed Temperate (MRT), Rangelands Arid (LGA) – Tanzania: Mixed Rainfed Arid (MRA) – South Sudan: Rangelands Arid (LGA)
West and Central Africa (WCA)	– Nigeria: Mixed Rainfed Arid (MRA) and Humid (MRH) – Burkina Faso: Mixed Rainfed Arid (MRA) – Ivory Coast: Mixed Rainfed Arid (MRA) – Senegal: Mixed Rainfed Arid (MRA) – Niger: Mixed Rainfed Arid (MRA), Rangelands Arid (LGA)
Latin America and the Caribbean (LAC)	– Brazil: Mixed Rainfed Humid (MRH) and Arid (MRA) – Honduras: Mixed Rainfed Humid (MRH) – Mexico: Mixed Rainfed Arid (MRA) – Guatemala: Mixed Rainfed Humid (MRH) – Colombia: Mixed Rainfed Humid (MRH)
South Asia (SA)	– India: Mixed Irrigated (MRI) and Rainfed Arid (MRA), Mixed Rainfed (MRH) and Irrigated Humid (MIH)
Central and Western Asia and Northern Africa (CWANA)	– Sudan: Rangelands (LGA) and Mixed Rainfed Arid (MRA) – Uzbekistan: Mixed Irrigated (MIT) and Rangelands Temperate (LGT) – Turkmenistan: Rangelands Temperate (LGT) – Kyrgyzstan: Rangelands Temperate (LGT), but relaxing the extreme poverty constraint
South-East Asia (SEA)	– Philippines: Mixed Rainfed Humid (MRH) – Indonesia: Mixed Rainfed Humid (MRH) – Laos: Mixed Rainfed Humid (MRH) – Vietnam: Mixed Rainfed Humid (MRH)

4.2. Challenge 2: Climate information systems do not reach many livestock producers, particularly those in remote areas

Hence, they lack literacy on climate prediction for risk management. Climate information systems also fail to effectively package their information for uptake and use.

Rationale and existing knowledge gaps

Climate information services (CIS, hereafter) involve the provision of information for decision-making. CIS are especially important in contexts in which short-term (weather through to seasonal) climatic variations have a significant impact on crop and/or livestock production and farmer livelihood (Vaughan et al., 2016). Climate services involve the co-production, translation, transfer and use of climate information to enable decision making (Vaughan et al., 2016). The range of agricultural decisions that can be informed using climate information is broad, and can include farm management, as well as the acquisition of services (such as insurance), inputs (such as fertilizer), pest and disease management, or even drastic changes in livelihoods (e.g., temporary, or permanent migration).

Various examples demonstrate the potential of CIS for informing decision-making in livestock systems in both developed (e.g., Frisvold and Murugesan, 2013; Furman et al., 2011) and developing contexts (e.g., Egeru et al., 2016). Despite the importance and potential of CIS in reducing the impacts of climatic variation, their use in livestock production systems is limited. Additionally, livestock producer and pastoralist decision-making vis-a-vis climatic variation is poorly understood. A recent global meta-analysis on climate services and decision-making showed that only 10% of the identified studies focus on livestock decision making (Born et al., 2021). Breuer and Fraisse (2020) highlight the importance of understanding decision-making processes and their drivers, as a fundamental input for the design of user-centric CIS. Notably, far less is known about how climate affects decision making beyond the production process itself (i.e., across the value chain).

Priority setting approach and synthesis of results

To identify geographic priorities, we followed a similar approach to Challenge 1. We consider the four components of CIS, namely, production, translation, transfer and use (Vaughan et al., 2016). The analysis required to first map hotspots with potential for CIS, and then characterize these hotspots within each country and livestock system in terms of rural population, value of production, tropical livestock units (TLU) and pasture area. TLU, value of production, and rural population data were the same as for Challenge 1 (Sect. 4.1).

Hotspots were defined as areas in which low adaptive capacity and high climate variability occur simultaneously with opportunities for the co-production, translation, transfer and use of CIS. Consequently, hotspots were identified using five dimensions, namely, adaptive capacity, climate variability, co-production potential, translation and transfer potential (analyzed together), and use potential. As a proxy of adaptive capacity, we used the 2018 poverty headcount ratio at US$1.9 per day (2011 PPP) as reported at the subnational level by the World Bank (World Bank, 2021). To characterize climate variability, we used the coefficient of variation of annual mean rainfall, derived from the CHIRPS dataset (Funk et al., 2015). Only areas with poverty rates above 10% and rainfall coefficient of variation above 15% were considered for analysis, and within these, the remaining dimensions (co-production, translation/transfer, and use) were analyzed. Areas of high potential for co-production are defined as having high seasonal climate forecast skill from IRI's seasonal forecast verification[2] (generalized area under the curve greater than 0.5), based on the assumption that high seasonal climate forecast skill would support the creation of CIS tailored to livestock systems. Areas of high potential for translation and transfer are defined as areas where mobile network coverage exists (based on the data of Mehrabi et al., 2020) in countries where a National Framework on Climate Services (NFCS) exists. Areas of high potential for use are those in which either the average education is below 9 years (i.e., literate, but not

[2] Available at https://iri.columbia.edu/our-expertise/climate/forecasts/verification/

finished high school) (taken from the Local Burden of Disease Atlas[3]) or the proportion of population without a bank account (from the World Bank Global Findex database) is greater than 50%, or both. We use these since they highlight either significant potential for building climate literacy, improving access to finance, or both. As a measure of gender gaps, we use differences in average education years between men and women (2 or more years of difference) and in the percentage of people with bank accounts (10% or more difference).

The resulting CGIAR-region CIS hotspots map is shown in Fig. 3. The map presents hotspots divided into five priority categories, and within each of these, significant gender gaps are highlighted. Areas considered as low priority (in light grey) are those with either high adaptive capacity or low climate variability. Areas of immediate and short-term priority (in red) have opportunities for all dimensions of CIS (co-production, translation/transfer, use). These areas are located across rainfed mixed crop-livestock systems in arid regions, especially in Eastern and Southern Africa, the Sahel, India, and to a lesser extent in Mexico and Central America. Rangelands and pastoral systems in Central Asia are also seen as short-term investment priorities. Areas of mid-term priority have opportunities for use, but limited opportunities for translation/transfer and co-production. These areas would require significant investment in improving seasonal forecast skill and mobile network infrastructure for CGIAR to deliver impact. Finally, long-term priority areas would require similar levels of investment to mid-term priority areas, but have less potential for CGIAR impact since according to the data it is likely that many farmers in these areas already have access to CIS, and financing for their activities (insurance, loans).

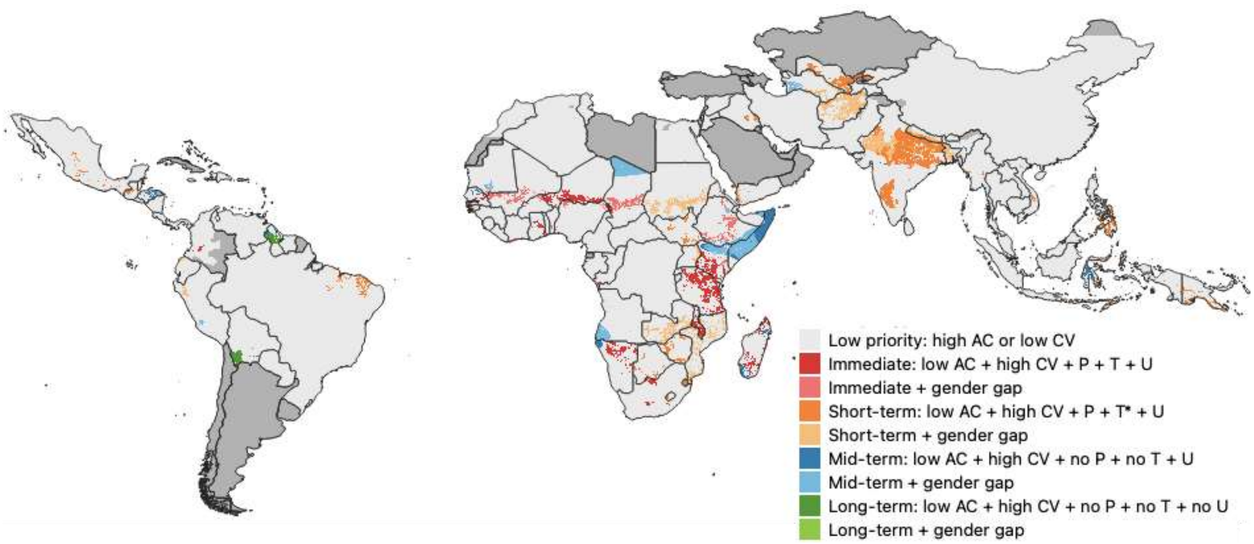

Figure 3 Potential hotspots for investment in climate information services. Areas in dark grey are data gaps for at least one of the variables used in the analysis.AC= Adaptive capacity, CV=Climate variability; P=co-Production, T= Transfer, U= Use of climate services

[3] Available at https://vizhub.healthdata.org/lbd

The characterization of CIS investment hotspots across livestock production systems across all CGIAR regions (Figure 4) shows that mixed rainfed and mixed irrigated systems in arid regions have the largest numbers of people, production value, and tropical livestock units. These systems are followed by mixed rainfed humid systems and arid rangelands, especially in terms of population and TLU (less so in terms of value of production). Pasture area is only useful to compare between rangeland systems, and within these, the arid rangelands show the largest amount of pasture area with CIS potential. The remainder of systems show minimal amounts of people, production value, TLU and pasture area. Table 4 shows a set of proposed geographic and system priorities for Challenge 2.

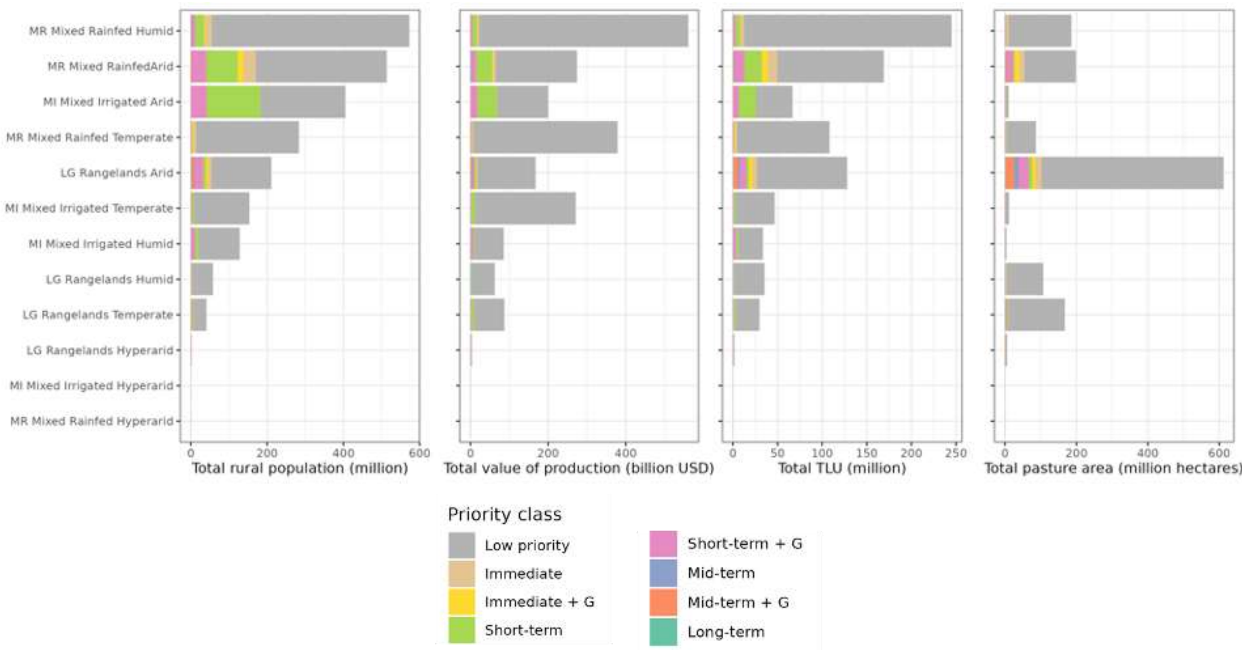

Figure 4 Hotspots for CIS across livestock production systems in all CGIAR regions. G= Gender gap

Table 4 Possible priority countries and systems for addressing Challenge 2

Region	Possible countries and systems based on priorities
East and Southern Africa (ESA)	– Kenya: Mixed Rainfed Arid (MRA) – Ethiopia: Mixed Rainfed Arid (MRA)
West and Central Africa (WCA)	– Senegal: Mixed Rainfed Arid (MRA) – Niger: Mixed Rainfed Arid (MRA); Rangeland Arid (LGA)
Latin America and the Caribbean (LAC)	– Colombia: Mixed Rainfed Temperate (MRT), mostly in the hillsides of the central and eastern Andes. – Guatemala: Mixed Rainfed Temperate (MRT) mostly in the highlands area toward western Guatemala (e.g., Huehuetenango)
South Asia (SA)	– India: Mixed Rainfed Arid (MRA), Mixed Irrigated Arid (MIA), mostly in the Ganges basin.
Central and Western Asia and Northern Africa (CWANA)	– Uzbekistan: Rangelands Temperate (LGT), Rangelands Arid (LGA), Mixed Irrigated Temperate (MIT), Mixed Irrigated Arid (MIA) – Turkmenistan: Rangelands Temperate (LGT), Mixed Irrigated Temperate (MIT) – Sudan: Mixed Rainfed Arid (MRA), Rangelands Arid (LGA) – Kyrgyzstan: Rangelands Temperate (LGT), provided the poverty constraint is relaxed somewhat (from 1.9 USD/day to 3.2 USD/day)
South-East Asia (SEA)	Not a priority

4.3. Challenge 3: Culturally embedded social norms and practices often limit or altogether marginalize women, youth or other vulnerable groups from benefitting from livestock.

Specifically, women and youth's limited ability to own, control and benefit from livestock often constrain their potential to benefit from RLE livestock strategies. This is true at all scales, from household production through to value chains, and in institutions and policy.

Climate change impacts, adaptation, and mitigation strategies affect people differently because of intersecting social factors that often include gender but may also include age and class or other context specific factors that shape power relations (Djoudi and Brockhaus, 2011; Ng'ang'a and Crane, 2020; Tavenner and Crane, 2018). Underlying structural inequalities, such as gender-based access to, ownership of, and potential to benefit from livestock, limit women's opportunities in households up through to livestock value chains (Njuki and Sanginga, 2013). In addition, youth – both women and men – also face unique age-based challenges, such as capital and insurance constraints (Bullock, R. and Crane, T.A. 2021; Mutua, E. et al, 2020; Bullock and Crane, 2020). Generating evidence about how technical adaptation and mitigation strategies interact with social differences is essential to support socially inclusive scaling of RLE livestock practices.

Rationale and existing knowledge gaps

Livestock are important for livelihoods and play an important role in supporting household's climate adaptation strategies. However, access to, ownership of, and ability to benefit from livestock often differs between men and women, reflecting gender-based roles and practices that cross multiple scales, from household social relations and into markets and value chains (Tavenner and Crane, 2018; Njuki and Sanginga, 2013; Kristjanson et al., 2010; Kinati, and Mulema, 2019). While literature has highlighted gender differences in productive agricultural resources, substantially less is known about gender and livestock (Njuki and Sanginga, 2013). Differential access to, use of, and management of agricultural and resources and livestock threatens both women and youth's ability to respond and adapt to climate change through measures such as diversification, adoption of forages, and digitally based risk management options such as climate information services (CIS) (Bullock et al., 2020; Manalo, J.A., et al. 2019; Ashley et al., 2018).

Land is another basic productive resource access to which shapes capacity to adapt to climate change. Social and gender norms, roles and practices often constrain women of all ages in the ownership and management of land, whether at the household or landscape scale. Many women do not have land titles and access land through husbands; patrilineal inheritance practices often deny women from inheriting land. In many cases women participate only marginally, if at all, in land governing institutions (Bullock and Kariuki, 2019). In rangelands contexts, women similarly seldom have the rights to manage land (Flintan, 2010). Customary institutions among pastoralist communities are often patriarchal (Flintan, 2010). For example, gender inequality is embedded and reinforced through and within water governance institutions and mechanisms (Cleaver and Hamada, 2010). Excluding women from institutions that govern the same rangeland resources that women use and depend upon, such as water and fuelwood, risks deepening gender inequality in access to natural resources. Together with climate change impacts, outcomes for women can be dire, particularly because gender roles often require them to fetch water, fuelwood and secure food for their households. Engaging women in formalized institutions and going beyond token participation will contribute significant progress in making implementation of climate interventions more equitable (Mandara et al., 2017). Participatory rangeland management (Flintan et al., 2019) has increased women's participation in committees and is a necessary step towards facilitating women's participation in decision-making processes at both local and landscape level. Women's membership in natural resource management (NRM) committees has the potential to empower women and change gender relations in the wider community.

The implementation of climate change adaptation and mitigation strategies need to redress the previously described structural inequities in order to ensure that RLE technologies do not reinforce unequal and unfair gendered divisions of labour and benefits. The introduction of new agricultural technologies and innovations impacts, and is impacted by, social dynamics (Bullock and Tegbaru, 2019) . In many instances the introduction of new technologies increases women's labour (Harman Parks et al., 2015 ; Nyanga et al., 2012). Similarly, processes of commercialization into lucrative livestock-based enterprises tend to disproportionately disenfranchise women (Crane et al., 2020) and may even generate conflict in household gender relations (Dolan, 2001). In rangelands, female headed households produce less fodder due structural inequalities previously mentioned, and limited opportunities to extension services (Omollo et al., 2018).

Climate change impacts will affect the ability of youths to secure livelihoods, incomes and food availability and it will be essential to engage youth in long-term adaptation[4]. While a fair amount of research has focused on gender and climate, much less attention has been given to youth and climate, so a focused research lens on understanding how age and other social factors may intersect and influence abilities of youth to adapt is needed. What attention has been given to youth has often been about the potential of agriculture as a source of employment (Ayele et al, 2017) . Despite scant empirical evidence, popular narratives about youth abound and often describe young people in simplified and narrow ways, often through use of age categories that overlook cultural values and transitions from youth to adulthood. Assumptions that youth are innovative, more tech savvy than older generations (Sumberg, and Hunt, 2019), and commercially oriented have, in many cases, guided the development of agricultural interventions that fail to bolster youth opportunity (Flynn et al., 2016)). Rather, youth opportunity spaces in agriculture are shaped by both geographic location and social contexts, including norms and practices (Sumberg et al., 2020). Gender norms can operate across generations, for example. Young women in rural areas often experience a double burden of being young and being a woman, especially in restrictive cultural contexts that limit women's mobility and opportunities to earn and manage income, for example (Bullock, and Crane, 2021; IFAD. 2019). Such youth-specific challenges also affect youth's abilities to access and benefit from climate de-risking options, that include climate information services (CIS). Rural youth face significant barriers to access both financial and non-financial services and the use of digital finance options can support youth in financial inclusion efforts (Gasparri and Munoz, 2019).

Few governments have adaptation strategies for livestock that specify priority interventions or plans to promote widespread uptake of such interventions. Policy support to both improve women's and youth's leadership in climate decision-making is needed and specific efforts to support rural youth in policy will be important (Trivelli and Morel, 2021). Women in agriculture will remain largely neglected by information and service providers unless their differing needs and access and control of resources are considered in policy (Kristjanson et al, 2017). Too often policies are developed by older generations. Meanwhile young people's capabilities may not be considered, or addressed, thus excluding young women and men. A greater presence of youth voice in climate policy is needed (Bullock and Crane, 2020). Specifically, youth need to be more actively engaged in climate change and agriculture-related decision making and policy processes across scales at local, national and global levels (Mungai et al., 2018). Advocacy activities should address the challenges faced by youth as they try to establish themselves in farming, including access to land, that remains one of the greatest challenges (Mungai et al., 2018).

[4] https://ccafs.cgiar.org/events/driving-global-youth-action-climate-adaptation-food-systems

Priority setting approach and synthesis of results

The LCSR initiative's prioritization has been led with an environmentally and economically driven system vulnerability methodology. As such, we will primarily take a **gender and youth responsive approach** to assessing and promoting technical livestock practices within these systems. Research activities will undertake a multi-pronged analysis of interactions between technical practices and social norms associated with gender and youth. Scientifically, the cumulative results relating to this challenge will elaborate the ways that RLE livestock practices interact with social norms and practices.

Programmatically, the results of this work will be synthesized in the form of practical decision support tools aimed at anticipating and addressing social norms in the planning, implementation and monitoring of RLE livestock scaling interventions. They will also lay the groundwork for more gender transformative approaches in the following phase of the initiative.

WP 1 will work with communities to engage women in Participatory Rangeland Management processes. The development of a novel and system specific tool, the Women's Empowerment in Pastoralism Index (WEPI) will track changes in women and men's empowerment in domains that include decision-making, leadership, and engagement in livestock activities, e.g. selling and buying. The tool will be useful to also identify potential mechanisms to empower women, such as collective action interventions.

To promote inclusive and equitable scaling of new technologies, WP2 will analyze emergent patterns of labour and benefit distribution in association with RLE livestock technologies. This evidence will then be the foundation for a decision-support tool for social inclusivity in the design and implementation of RLE technologies, as well as in adaptation tracking protocols developed in WP5.

A better youth specific understanding of what young women and men are doing in agriculture and more specifically, a better understanding of how the livestock sector may support youth employment (Swarts and Aliber, 2013) and abilities to adapt to climate change is needed to usher in the next generation's adaptive capacity in an uncertain future (IFAD. 2019)**.** To that effect, WP3 considers how both gender and age may influence access, use, and potential to benefit from climate information (Bullock and Crane, 2021).

Environmental and socioeconomic benefits linked to livestock-based climate finance will generate trade-offs in economic, environmental and social opportunities. These must be understood to support more socially equitable performance such that climate finance does not marginalize social groups that may include women and youth. Increasing the number of policies that support social inclusion in the livestock sector and climate adaptation will strengthen the potential for sustainable and equitable social change in the face of climate change.

4.4. Challenge 4: Livestock are responsible for a significant proportion of national and global GHGe

These are from direct enteric emissions, manure and soil emissions, land conversion and production inefficiencies

Rationale and existing knowledge gaps

LAFS are responsible for nearly 12% of global annual emissions directly from enteric methane and manure management, and indirectly through emissions driven by feed production, land use change, processing, and transportation (Crippa et al. 2021). Animal-based foods contribute about double food-derived GHG emissions that plant-based foods—57% vs 29%, respectively (Xu et al. 2021). The primary sources of land-based emissions differ by region. Though the proportion of emission directly from livestock is relatively small in every region, livestock in fact are responsible for an outsized part of land-based emissions. Cattle production for example has driven about 3.0 million ha of forest loss each year 2000-2015 (Goldman et al. 2020), an area about the size of Denmark. In most countries of the Global South livestock-related emissions represent the largest fraction of their land use GHG budgets which for many African countries is the sector with the most emission.

Priority setting approach and synthesis of results

Our prioritization considers livestock emissions derived from direct enteric emissions, manure and soil emissions, and land conversion. Direct emissions data for all livestock is provided by Herrero et al. (2013). As the data are from 2010 we have estimated contemporary emissions by multiplying 2010 values by the proportional increase in livestock emissions[5] from 2010 to 2019 as reported in FAOSTAT (FAO, 2021). Estimates of emissions from land conversion combine spatial soy[6] and pasture driven forest loss data for 2010-2015 (Goldman et al., 2020) with above ground biomass (AGB) data from 2010 (Spawn and Gibbs, 2020). Whilst the data used here are adequate indicators for the comparison of geographies and systems, we do recommend that the absolute estimates of emissions are **not** quoted in reporting. Soil emissions are difficult to quantify directly, therefore we use % change in rangeland soil organic carbon (SOC) content data from Trends.Earth[7]. SOC content is masked to GLPS Rangelands (Figure 1) and non-protected areas (World Database on Protected Areas – UNEP and IUCN, 2009). See here for further details on the datasets. The figures below are generated using an interactive *Rmarkdown* script that can be used to merge or disaggregate emission sources then analyze them at regional, national and subnational scales.

[5] Emissions (CO2eq) from CH4 (AR5) plus Emissions (CO2eq) from N2O (AR5) from Enteric Fermentation, Manure applied to Soils, Manure left on Pasture and Manure Management.

[6] Note that we assume most soy grown in recently deforested areas is for livestock feed. Globally 77% of soy production is used as animal feed, and recent increases in demand for soy are linked to growth in production of animal feeds, biofuels, and vegetable oils predominately. Poultry (37%) and pig (20.2%) feeds account for more than half of global soy production, whereas beef and dairy feeds account for only 1.9%. See here for export/import information regarding soy.

[7] https://trends.earth/docs/en/background/understanding_indicators15.html#soil-organic-carbon

Livestock emission hotspots were defined by summing emissions from the sources analyzed. A few trends emerge. First and foremost, mixed systems, and especially those in arid and semi-arid lands, generally dominate in terms of emissions (Fig. 5). Conversely, irrigated systems and rangelands in temperate regions show the lowest total emissions. Secondly, emissions from two countries –Brazil and India, exceed all others by far. In most cases the emissions from Brazil and India triple or more those of other countries. Secondly, this is largely driven by the significant cattle populations in these countries (Fig. 6). Beef and dairy cattle tend to have the highest emissions, despite variation based on management (Poore and Nemecek, 2018). Accordingly, Latin America and South Asia dominate in terms of emissions at the global scale. Lastly, the greatest contributor to GHGe is bovine production, followed by land use for pasture, and sheep and goat production.

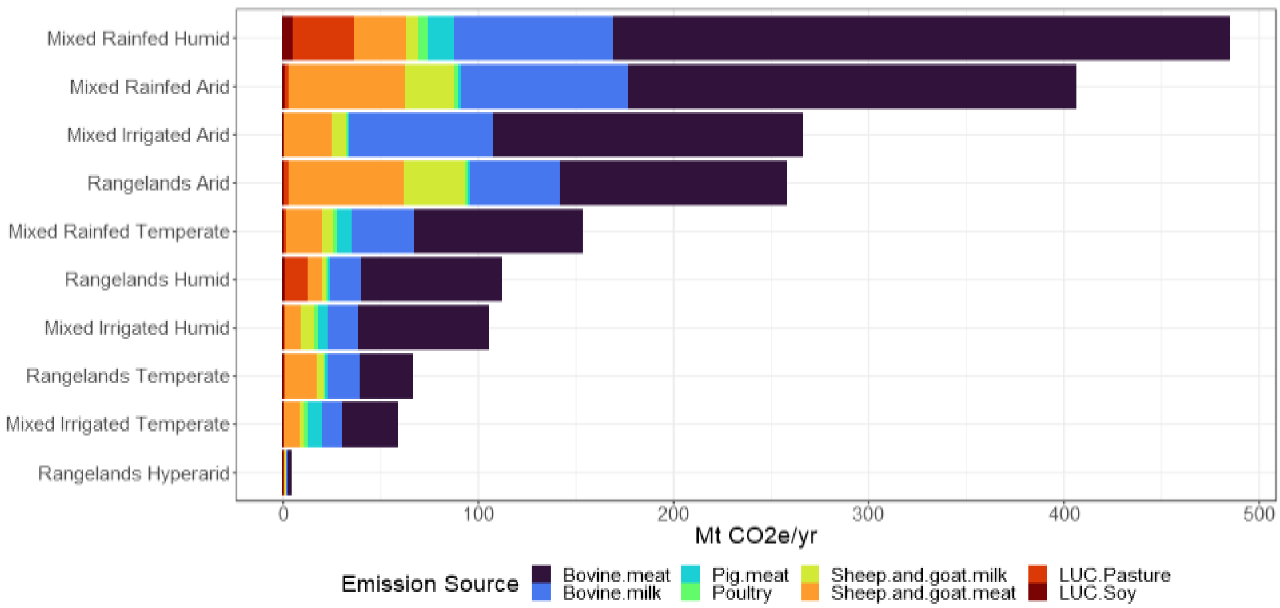

Figure 5 Direct and forest conversion emissions by livestock system

Figure 7 shows the proportion of rangeland per country with declining soil organic carbon content (a proxy for rangeland degradation) per country. These results suggest that the greatest rangeland degradation occurs in South Asia and South-East Asia (>60% area), followed by southern West Africa (50–60%) and Latin America (40–50%). Significant proportion (40–50%) of rangeland area with declining SOC is also seen in several countries of the CWANA region including Tunisia, Kyrgyzstan, Tajikistan, Syria, amongst others. A global ranking of countries is shown in Fig. 8, and a possible list of priorities for mitigation and rangeland management actions is shown in Table 5.

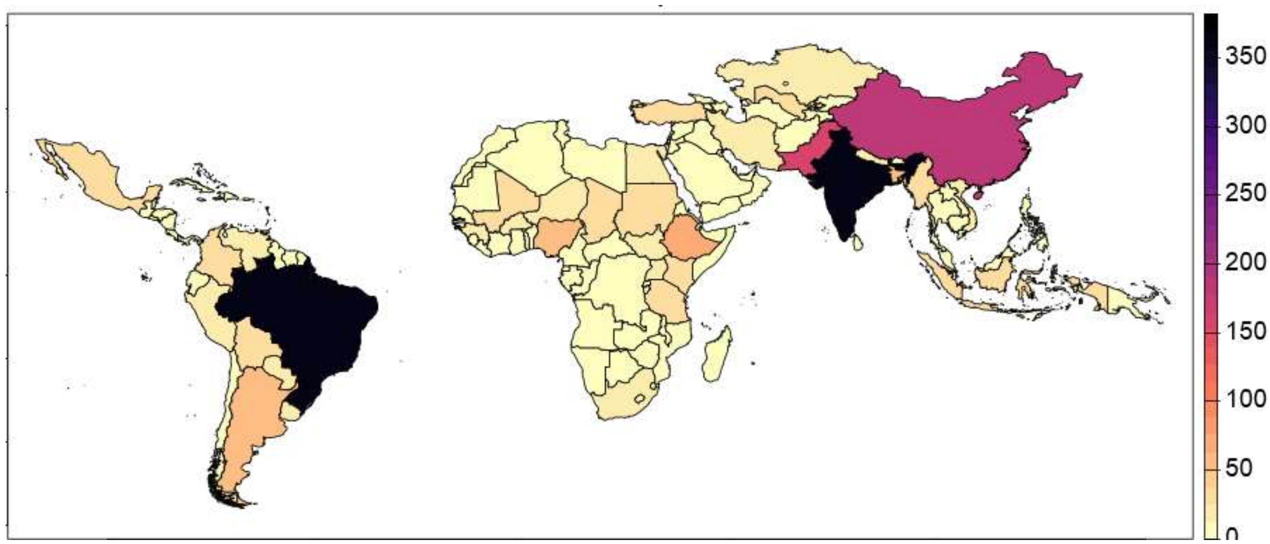

Figure 6 Direct and land-use conversion livestock emissions by country (Mt CO_2-e yr^{-1})

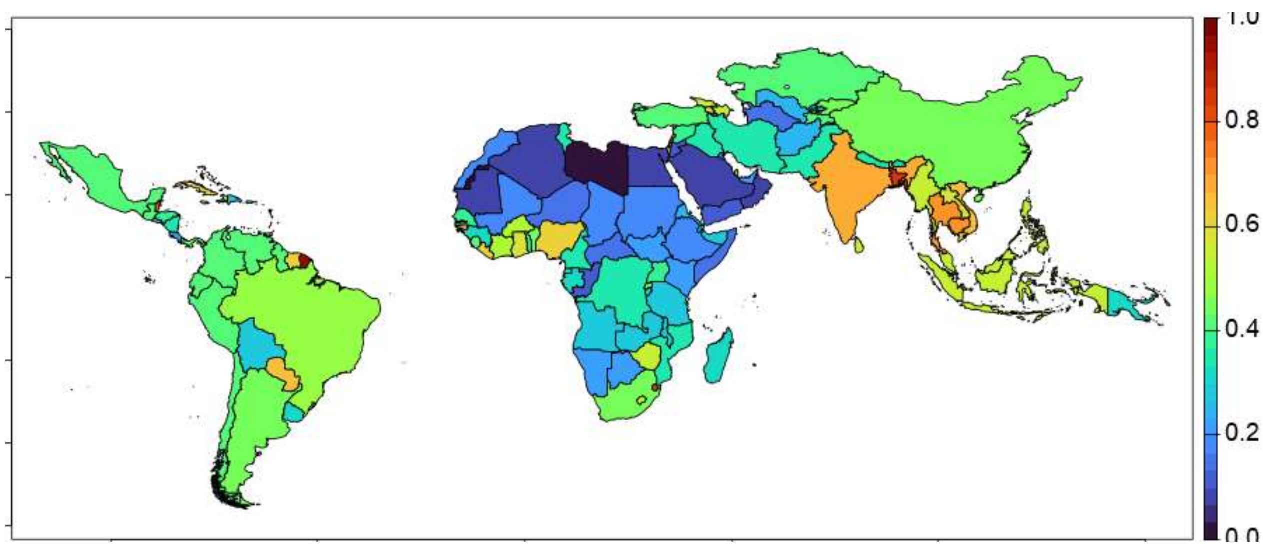

Figure 7 Proportion of rangeland with declining SOC by country

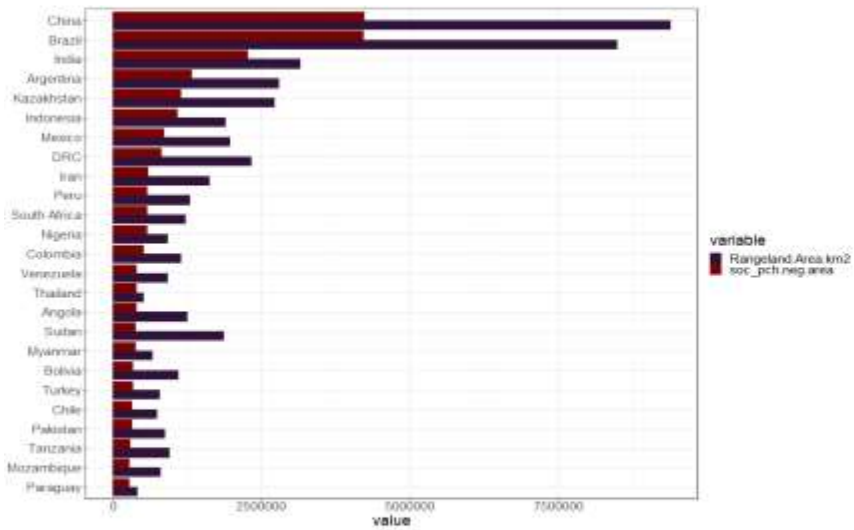

Figure 8 Total rangeland area and declining rangeland area, ordered by the latter for the 25 countries in CGIAR regions with the largest area of declining rangeland.

Table 5 Possible priority countries for Challenge 4. Numbers next to countries/regions are estimates of total livestock emissions (Mt CO_2e/yr), livestock %s indicate share of emissions. SOC (soil organic carbon) column: % and total area of rangeland with declining SOC.

Region	Total Livestock Emissions and Major Contributors	SOC decline
ESA 259.7	Ethiopia 77.4 - Cattle 85.6%, Shoat 7.4% Kenya 37.8 - Cattle 70.4%, Shoat 29.1% Tanzania 33.2 - Cattle 78.6%, Shoat 19.4%	20%, 0.23M km2 23.3%, 0.14M km2 29.3%, 0.28M km2
WCA 237.2	Nigeria 58.9 - Cattle 65.2%, Shoat 18.3% Chad 28.8 - Cattle 83.1%, Shoat 16.8% Mali 26.5 - Cattle 79.3%, Shoat 20.5% Burkina Faso 24.8 - Cattle 77.8%, Shoat 21.3% Niger 24.3 - Cattle 72.2%, Shoat 27.7%	62.4%, 0.57M km2 20.6%, 0.26M km2 20.2%, 0.25M km2 54%, 0.15M km2 14.5%, 0.17M km2
LAC 670.1	Brazil 380.3 -Cattle 68.5%, LUC pasture 25% Argentina 64 - Cattle 88.3% Colombia 31 - Cattle 97.2% Mexico 38.7 - Cattle 80.6%, Shoat 9.4%, Pigs 5.5% Bolivia 37.1 - LUC pasture 52% , Cattle 27.7%, LUC soy 14.3%	49.6%, 4.21M km2 47.4%, 1.32M km2 44.6%, 0.51M km2 43.9%, 0.86M km2 30.8%, 0.34M km2
SA 632.1	India 382.2 - Cattle 89.1%, Shoat 10.4% Pakistan 162.2 - Cattle 80.5%, Shoat 19.2% Bangladesh 58.7 - Cattle 77.6%, Shoat 21.8%	71.6%, 2.26M km2 36.3%, 0.32M km2 88.1%, 0.12M km2
CWANA 227.2	Sudan 34.5 - Cattle 60.6%, Shoat 39.3% Uzbekistan 26.5 - Cattle 84.5%, Shoat 15.2% Iran 24 - Shoat 54.3%, Cattle 44.2%	20.5%, 0.38M km2 25.3%, 0.11M km2 36.3%, 0.59M km2
SEA 322.3	China 195.6 - Cattle 62.4%, Pig 17.1%, Shoat 16.9% Indonesia 39.2 - Cattle 68.8%, Shoat 11.6%, Poultry 7.8% Myanmar 35.3 - Cattle 91.4%	45.1%, 4.23M km2 57.4%, 1.08M km2 56.6%, 0.38M km2

4.5. Challenge 5: Public and private investors including climate finance are reluctant to invest in livestock production

This is due to a generalized negative perception of livestock due to potential harms to the environment (e.g., deforestation, GHG emission) and perceived financial risks (e.g., in pastoral systems). In addition, reliable monitoring systems are not in place to monitor, verify and report nature-positive impacts realized by the investments.

Rationale and existing knowledge gaps

From Paul et al (2020): "Livestock has been universally criticized for its large contribution to greenhouse gas (GHG) emissions, land use change, soil degradation, water use and loss of biodiversity (Steinfeld et al 2006, Herrero et al 2015, Hilborn et al 2018). Global media continues to be dominated by concerns about adverse environmental and health impacts of livestock, while the coverage of livestock's contribution to livelihoods has been declining (Marchmont Communications 2019).

4.6 Challenge 6: Rangelands are under severe and diverse stress from climate change, degradation, and deterioration, yet there is a significant gap in investment in rangeland restoration and improvement

Rationale and existing knowledge gaps

Over two billion people depend on the world's pastoral agrifood and livestock production systems found mainly in rangelands (FAO and CIRAD, 2020; Seid et al. 2016; UN Environment Group, 2011; Notenbaert et al., 2012; Nyariki and Amwata, 2019; Neely et al., 2009) covering approximately 54% of the world's terrestrial surface with 50% of the world's livestock (ILRI et al., 2021).

The benefits of rangelands have not been fully appreciated. Broadly speaking protected areas in rangelands cover 9,438,874 km^2 plus an additional 344,790 km^2 proposed, that is 7% of global terrestrial surface. Of rangelands worldwide, 1.7% are classified as confirmed key biodiversity areas (KBAs) – that is 1,341,354 km^2 of total rangeland area of 79,509,421 km^2 (ILRI et al 2021, Rangelands Atlas). Beyond these broad figures there are significant gaps in data on rangelands. A significant UN report in 2019 underscored these significant data gaps under the title, "A Case of Benign Neglect: Knowledge Gaps About Sustainability in Pastoralism and Rangelands".

What is known is that these systems are experiencing intensifying impacts from climate change and other forces (Herrero et al., 2016; Cervigni and Morris, 2016; Oyango et al., 2021), therefore exacerbating vulnerability and weakening resilience especially to climate-related shocks (FAO, 2018; Ayal et al., 2018). Land degradation, productivity losses (Haddad et al., 2021; Oyango et al., 2021), conflicts, food insecurity and displacement of populations (Cervigni and Morris, 2016; Haan et al., 2016) have resulted. A lack of appreciation and appropriate investment in pastoralism has meant not only weakened resilience, but also meant that the full potential of these systems has never been realized.

There is a lack of knowledge and capacity to support a (re)building of this resilience (Douxchamps et al., 2017; GIZ, 2014) leading to governments and other stakeholders making decisions that fail to address root causes of resilience weakness whilst relying on increasing humanitarian aid (EC 2019). Development interventions have been driven from outside communities, and the agency of pastoralists has not been fully tapped – particularly women and youth (Layne Coppock et al., 2013; IFAD, 2012; Flintan, 2008; Ancey et al., 2020; CDKN, 2021; BSR et al., 2018).

Higher productivity areas with permanent access to water such as riverine lands have been converted to crop farming. This has been shown to have high economic and environmental costs placing the whole rangeland system at risk as without access to these lands for dry season grazing, it is impossible to use the rest of the rangeland effectively (Behnke and Kerven, 2013). Furthermore, cropping lands have blocked migration routes for both livestock and wildlife, and grazing lands and wildlife habitats have been increasingly fragmented. National boundaries have split rangeland ecosystems. Additionally, with extra livestock pressures on remaining land, coupled with impacts of such as government policies and climate change leading to higher temperatures and more erratic rainfall (reduced in some places, increased in others), land degradation has increased together with a loss of animal productivity, wildlife and biodiversity (Oyango et al., 2021). New challenges such as significant increases in the incidences of invasive species have made matters worse, with communities and other local land managers lacking capacity and knowledge to address these new threats.

The sustainability of these systems is further challenged by significant need for land and resource restoration and rehabilitation which falls way behind those in other systems such as forests (Haddad et al., 2021; Andrieu et al., 2017; CDKN, 2021; Cervigni and Morris, 2016; IISD, 2016). Non-supportive policy and legislation further prioritize investments in other agrifood systems that lead to further marginalization, exclusion of pastoralists and other local stakeholders and can be a root cause of conflicts (Laderach et al., 2021; FAO & IUCN, 2016; FAO, 2016; IFAD, 2018; AFSA, 2017). Though there have been signs in a shift of thinking amongst some member states and within the global arena - see for example the Ndjamena Declaration, Nouakchott Declaration and Kiserian Declaration - this has not led to any appreciable investment in rangelands particularly from the private sector. And though the world has seen a phenomenal increase in global efforts to restore land, the majority has been targeted to forests and planting of trees. On the contrary, this effort has in fact put rangelands at greater threat as several tree-planting initiatives have seen rangelands as vacant ground for these. In general, investments in rangelands including grasslands and savannahs are significantly behind that of forests.

The linkages with livestock-based value chains particularly targeting women and youth have not been fully explored and exploited: increasing the value of livestock and incomes from them can result in a higher appreciation of their value and more investment in ensuring a healthy resource base. This is even though over the last two decades the risk environment has improved with infrastructure and communication linkages increasing, improved access to basic services for local populations and markets, better drought management programs, reduced conflicts, amongst others.

Land degradation neutrality (LDN) provides a framework for addressing these threats[8]. However, response options for achieving LDN in rangelands are restricted due to, amongst other, poor science-based and up-to-date evidence and data on rangelands (distribution, status, economic value including of ecosystem services and investment benefits), few documented good practices of rangeland restoration (particularly at scale), limited understanding of risks and opportunities for investment particularly amongst the private sector, lack of coordination (at regional/continental and national levels) and low capacity amongst governments to restore rangelands at scale including working with local rangeland users and/or communities (Oyango et al., 2021). Despite a limited number of relatively small-scale, project-based rangeland interventions and investments, global and regional actors and national governments have been slow to commit to large-scale restoration and public-private partnerships are scarce.

Priority setting approach and synthesis of results

According to climate change simulations rangelands can expect changes in the coefficient of variation of annual rainfall by 2050. Some 12% (ca. 9,000,000 km^2) rangelands globally can expect to see greater than 35% change; 10% (8,000,000 km^2) can expect 30-35% change; and 20% (16,000,000 km^2) can expect 25-30%. Other changes are also projected. Approximately 12% of rangelands are projected to have more than a 20% loss of length of growing period between by 2050, and in 4% of rangelands the minimum temperature will likely flip from below 8ºC on average to above 8ºC on average by 2050. In around 16% of rangelands the average maximum temperature is projected to flip from below 35°C currently to greater than 35°C by 2050. This flip will be a critical threshold for rangeland vegetation and heat tolerance in some species (ILRI et al., 2021).

Future projections suggest that 27.74% (22,053,984 km^2) of all rangelands will likely be affected by climate change as per the three thresholds listed above. More than half (56.45% or 6,547,681 km^2) of Tundra, 39.21% (10,973,597 km^2) of deserts and xeric shrublands, 22.54% (247,034 km^2) of flooded grasslands and savannas, 13.17% (685,299 km^2); of Mediterranean forests, woodlands and scrub, 6.78% (685,299 km^2) of temperate grasslands, savannas and shrublands, and 10.23% (2,076,697 km^2) of tropical and subtropical grasslands, savannas and shrublands are projected to be affected by climate change (see three thresholds above) (Fig. 9).

[8] https://www.unccd.int/actions/ldn-target-setting-programme

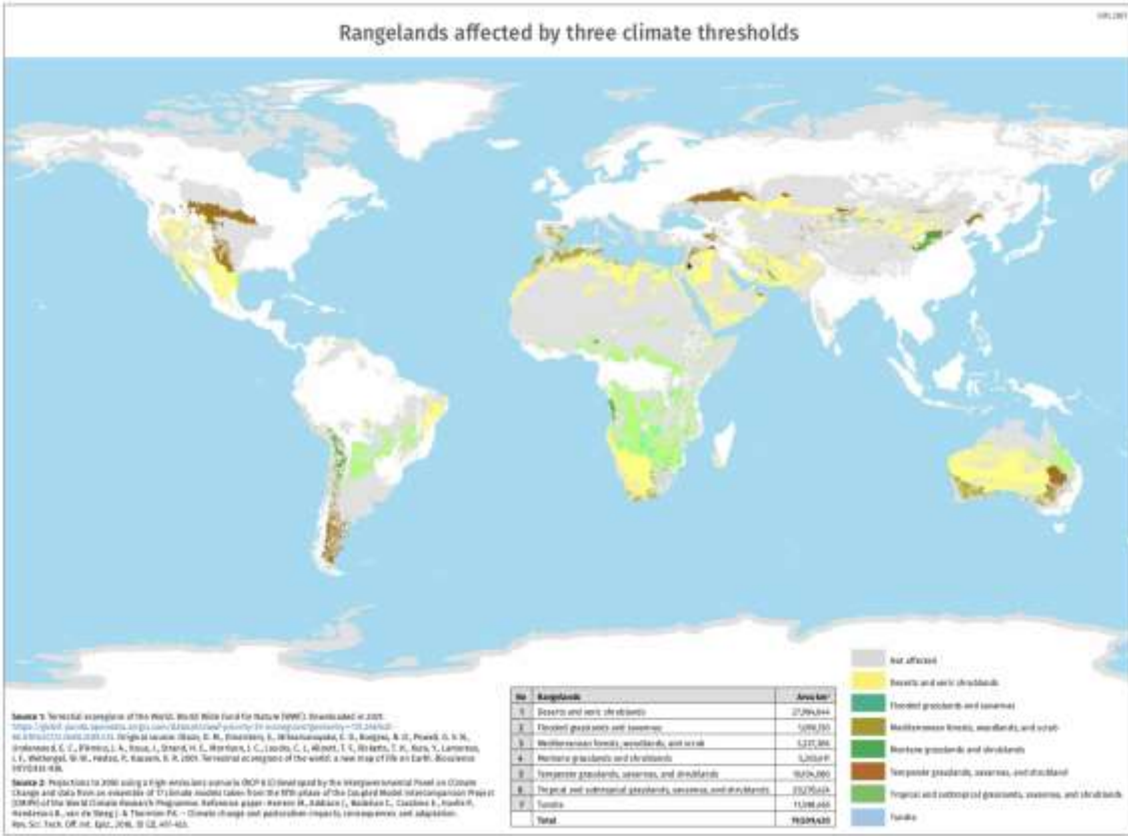

Figure 9 Rangeland ecosystems affected by three climate change thresholds, namely, reductions in the length of the growing period of more than 20%, flips in temperature from below 8ºC to above 8ºC, and flips in temperature from below 35ºC to above 35ºC, all by 2050.

Future climate projections also suggest that approximately 31% of rangelands will be affected by one or more climate change thresholds by 2050. Approximately 12 million km^2 is projected to be affected by a maximum temperature of average 30°C, and 9.6 million km^2 will likely be affected by a shorter growing season. A further three million km^2 will likely be impacted by annual temperature over 8 degrees. It is projected that approximately 13 million km^2 of deserts and xeric shrublands, 7.5 million km^2 of tropical and subtropical grasslands, savannas and shrublands, and two million km^2 of temperate grasslands, savannas and shrublands will likely be affected by 1-2 of the three climate change thresholds. Most (approximately 17.6 million km^2) rangelands will likely be impacted by one climate change threshold, and 3.3 million km$_2$ will be impacted by two climate change thresholds. No rangeland area is affected by all thresholds together (ILRI et al., 2021).

While a country prioritization based on the information available on climate change impacts on rangelands, as well as on rangeland degradation remains challenging, rangeland management and resilience building programs need to take place across northern Africa, Central Asia, the Sahel, and Eastern and Southern Africa. In Latin America, only Colombia has significant area under rangelands, with ca. 50% experiencing SOC decline, and 15–20% affected by the three climate change thresholds. Based on the results presented in Fig. 7 (percentage rangeland area with declining SOC) and the climate change thresholds of Fig. 9, we propose Senegal and Mali (WCA); Tunisia, Kyrgyzstan, and Tajikistan (CWANA); Ethiopia, Kenya and Tanzania (ESA); and Colombia (LAC), as key priorities for rangeland management and restoration.

4.7. Challenge 7: Development and climate policies pertaining to livestock are not well coordinated and lack coherence

The former fail to account for either climate adaptation or mitigation targets. The latter are not always cognizant of the economic development targets or strategies.

Rationale and existing knowledge gaps

Many countries are now transitioning from the conventional development state to a more environmentally sustainable development state that focuses on reducing emissions from the productive sectors of the economy. It is widely accepted that the best way to address climate change impacts on the poor is by integrating adaptation responses into development planning. Many international organizations are assisting countries, especially developing countries, to transition to a green economy where the environment is prioritized. In 2006, OECD Development and Environment Ministries and Agencies began a series of processes to work with developing countries to integrate environmental factors efficiently into their national development policies and poverty reduction strategies (OECD, n.d). Similarly, development and environment agencies are required to ensure that their efforts support the mainstreaming of climate issues into general sustainable development. Others, such as the UN Organizations, also offer opportunities for sustainable development and implementation of measures and actions to be integrated into poverty reduction strategies.

Building climate change policy on sustainable development priorities is necessary at national and global levels (Winkler, 2003). Policies formulated at both stages need to be coherent with sustainable development if climate change targets are to be met. Though developing countries are highly susceptible to the harmful effects of climate change from a development perspective, climate change and its issues are less of a priority because they prioritize meeting basic development needs. Climate change does not feature prominently within many developing countries' environmental or economic policy agendas (OECD, n.d). Climate actions are often put in two distinct categories: mitigation and adaptation. The separation has led to the misinformed view that addressing climate change means pursuing either mitigation or adaptation. It is, therefore, not surprising that most developing countries do not commit to implementing sustainable development (Winkler, 2003). The reality is that adaptation and mitigation are two sides of the same coin. Adaptation and mitigation practitioners, decision makers and scientists, however, tend to form separate communities. However, those engaged in mitigation should be informed about adaptation, and vice versa, and participants in both groups should be trained in the other group’s tools and methods. Additional tools, methods and evidence are needed, both to enhance the possible benefits and to reduce any adverse effects the two approaches might have on each other. In addition, international and national policies and standards can support the integration of mitigation and adaptation, by actively encouraging synergies and by making adaptation a requirement of mitigation projects (Locatelli, 2014).

The livestock sector is essential in many countries due to its significant role in meeting food security, improving livelihoods, and increasing incomes and the economy's gross domestic product (GDP) (Ashley, 2019). Countries such as Kenya, Ethiopia, and Uganda all have vibrant livestock sectors that have contributed immensely to the development of their economies. They have an economy strongly linked to increased emissions from increased production to meet growing demand. It is expected that policies formulated to address climate change should follow a sustainable development framework approach.

Both adaptation and mitigation policies in the livestock sector need to be strong and coherent with existing national development plans. However, the challenge is that most of these policies are distinct in their numerous sectors and were not formulated with environmental sustainability in mind. They fail to address the current dispensation where climate change is expected to be integrated into development agendas and actions. According to Ashley (2019), climate change policies, agricultural policies, livestock policies, development policies, and environmental policies are not strong and coherent in addressing livestock sector adaptation and mitigation. Most of the national development policies do not have livestock climate change strategies integrated into those policies to minimize emissions from livestock production. Even those that have integrated such strategies into the policies are not very coherent and contain less detail (Ashley, 2019). There is also the absence of fiscal space available for most countries in the developing world to finance and implement priority actions contained in many development and livestock policies on climate change adaptation and mitigation (CCAFS, 2019).

Gerber et al. (2010) identified several challenges peculiar to the livestock sector about climate change. Acknowledging the technical opportunities in the livestock sector to mitigate, including sequester carbon on grazing lands, mitigating carbon losses from soils used in feed production, reducing enteric fermentation in ruminants, the authors indicated the lack of incentive-based policies and standards to encourage the adoption and diffusion of these technical options. Additionally, because there are many distinct livestock production units and a disconnect between interactions between production practices, technologies, and emissions, many countries have experienced complications in designing and adopting economically efficient and administratively feasible policy measures (Gerber et al., 2010). There is a general lack of simple approaches that can accurately quantify the emissions reduction and carbon sequestration, which has hindered the development of mitigation policies for the livestock sector (Gerber et al., 2010). Another major challenge is implementing effective mitigation policies that face the challenge of addressing multiple – and often conflicting goals, including poverty reduction, economic growth, and the protection of natural resources. Since most countries in the developing world are reluctant to adopt policies that raise the costs of production, there is the need to ensure that mitigation policies that are enacted are those that can enhance production efficiency, increase farmers' incomes, and reduce food costs. Hence, policies and strategies that aim to lower GHG emissions while producing economic and environmental co-benefits need to be the main focus when addressing climate change from the development point of view. New climate change policies devoid of substantial political and administrative influence with a focus on incentive provision to enhance mitigation and adaptation by players in the livestock sector are needed to address climate change.

Priority setting approach and synthesis of results

From a development point of view, policies that seek to address GHG emissions from agriculture (including livestock) need to be economically viable, ecologically sound, and socially acceptable (World Society for the Protection of Animals, 2012). The policies need to impact sustainable food production positively. They must be coherent with climate policies that deliver environmental protection, reduce GHG emissions, and ensure good animal welfare, public health, and meat quality. Any mitigation of emissions from livestock must be based on high animal welfare standards to enhance the potential for reducing emissions (World Society for the Protection of Animals, 2012).

Climate change mainstreaming into policy agendas, government policies, and initiatives has resulted in many countries embarking on an agenda to integrate these into development agendas. Largely, countries that have embarked on integrating adaptation into their development strategies are on the right course (OECD, 2004). This must be backed by institutional strengthening, effective management of public finances, strong human capital, and sound management of natural resources (Adger et al., 2003). Recent developments have shown that many countries, in their policy development processes, have designed policies that provide a more comprehensive set of approaches and strategies coherent with climate change policies and align with other national and international policies and guidelines (especially the SDGs). Support from the international community, development partners, and other key players in sustainable development and climate change has been a phenomenon in terms of technical assistance and financial support to develop livestock sector adaptation and mitigation policies. These policies are predominantly common in the climate and development policy areas and are available for livestock, agriculture, and land sectors.

There have been several success stories in some African countries where livestock is prominent and contributes to agricultural growth. Specifically, Kenya has developed policies across many policy areas that support climate change adaptation (Ashley, 2019). These policies regularly call for finding adaptation-mitigation synergies though it is argued that there is little guidance provided to achieve this. Similarly, in Uganda, most of the country's development policies identify the importance of agriculture to the economy but provide limited references to livestock sector mitigation though enough information exists on strategies for livestock adaptation. Climate policies focused on adaptation tend to integrate livestock sector adaptation. However, other climate policies and other policy areas are weaker on this integration. More recent climate policies and the development policy in Ethiopia support livestock adaptation while livestock, agriculture, land, and environmental policies are less explicit. There is policy coherence for livestock adaptation in development policy and more recent climate policy but a lack of adaptation consideration in livestock, agriculture, land, and environmental policies.

Another distinct way to integrate livestock and climate policies in development agendas is the contribution to global climate change standards through their Intended Nationally Determined

Contributions (INDCs). These represent their actions to contribute to addressing climate change as contained in the Paris Agreement. Ever since the agreement was put in force, the NDCs are no longer "intended" but represent the targets, policies, actions, and measures that Parties have agreed to implement domestically (Fransen et al., 2019).

Agriculture production, including livestock, contributed about 13 percent of total global emissions in 2016 through direct GHG emissions (Climate Watch 2019a). Projections show that emissions from the agricultural sector will increase substantially due to the growing demand for resource-intensive foods like meat and dairy in the middle- and higher-income countries due to increased use of fertilizer and income rise (Searchinger et al., 2019). Therefore, ensuring the alignment of the national development policies with global climate change targets is critical.

Countries have responded by focusing more on the agricultural sector by presenting actions that will significantly reduce emissions and strengthen adaptation and support. Figure 10 shows how countries across the globe responded to agriculture in their INDCs.

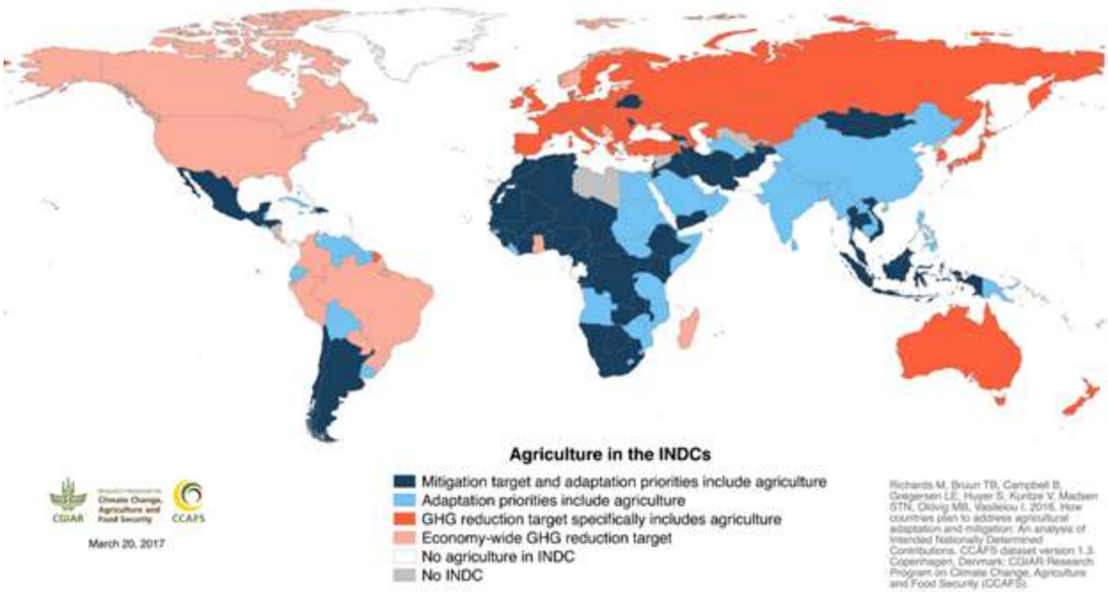

Figure 10 Agriculture in the INDCs. Taken from Richards et al. (2016)

A review of countries' 2015 and 2016 commitments to climate change mitigation and adaptation carried out under the CCAFS project shows that out of a total of 162 pledges for climate action (INDCs), 104 (in red) intend to make emission reductions in agriculture, and 127 (in blue) list agriculture as a priority for adaptation. The report also shows that an additional 15 countries (in light red) have economy-wide mitigation targets in agriculture. Most of the NDCs had a program that focused on crops and livestock management, including water management and irrigation (FAO 2016a).

Similarly, a review of the livestock systems in the INDCs of countries submitted to the UNFCCC shows that 61 countries mentioned livestock as a priority for mitigating climate change, as shown in red in Fig. 11. Similarly, 61 countries also have the livestock sector as their adaptation priority, as shown in blue.

Particularly important is the number of countries with livestock-related mitigation and adaptation (shown in purple) in their respective NDCs. All these actions in the NDCs are backed and supported by public policies in either their agricultural sector or the livestock sector.

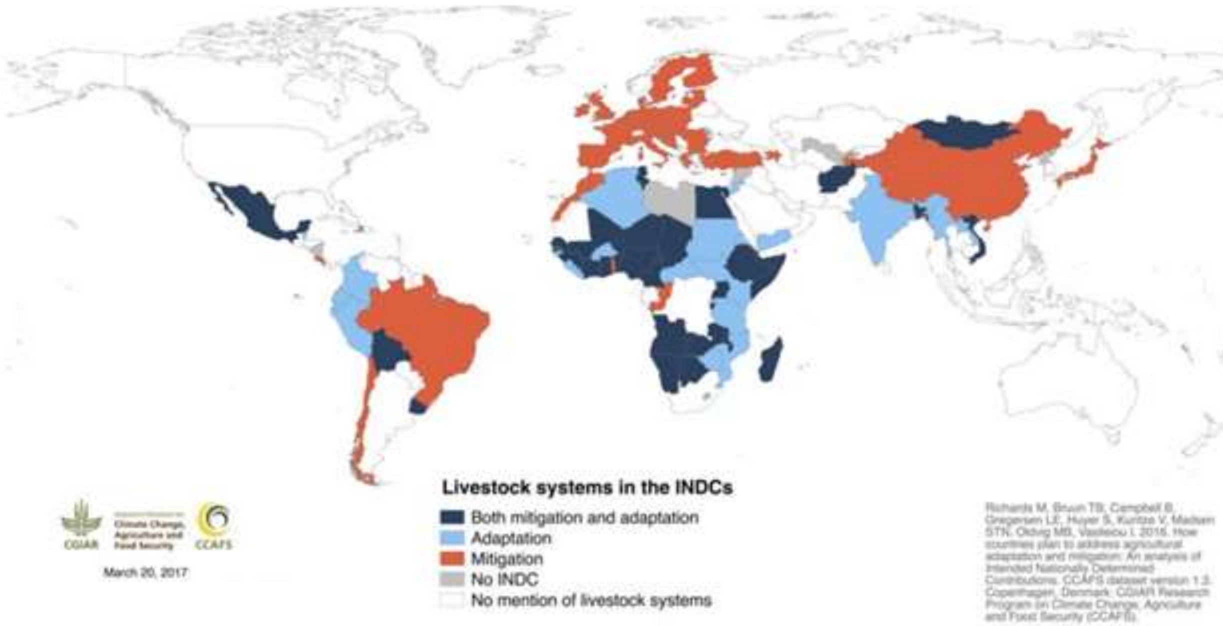

Figure 11 Livestock systems in INDCs. Taken from Richards et al. (2016)

Countries must put policies to ensure that increased production in the sector does not significantly affect global climate change emission levels. Many countries have responded to this through supportive policies, adequate institutional and incentive frameworks, and more proactive governance to meet their mitigation and adaptation measures in their NDCs. In responding to the development of the livestock sector, countries have determined to ensure that policies they put across include practices and technologies that reduce emissions while simultaneously increasing productivity in the sector and contributing to food security and economic development. For example, in Ghana, the response to deal with threats of climate change in many sectors of the economy led to the country pursuing coordinated domestic policy actions that integrate adaptation, mitigation, and other climate-related policies within broader development policies to build a climate-resilient economy. The country's mitigation and adaptation actions in its NDC should align with its medium-term development agenda and other development plans. Agriculture is one of the broad sectors where the priority adaptation policy actions have been formulated to help achieve climate change adaptation goals. The goal is to build resilient agriculture in climate-vulnerable landscapes by scaling up the penetration of climate-smart technologies to increase livestock and fisheries productivity by 10% (Government of Ghana, 2015). This is supported by national policies such as the Food and Agricultural Sector Development Policy (FASDEP), the Medium-term Agricultural Sector Investment Plan, and the Ghana Agricultural Sector Investment Programme. These actions, when well implemented, will help increase climate resilience while decreasing vulnerability for enhanced sustainable development.

In some countries, their NDC mitigation actions are formulated to align with their public policies of using several technologies to help reduce emissions in the livestock sector. Some of the interventions that have been adopted to reduce emissions in the livestock sector support both adaptation and mitigation while meeting development goals in the livestock sector. Particularly, according to Gerber et al. (2013), some countries have adopted the use of promising technologies and practices such as the use of better-quality feed and feed balancing to lower manure emissions, improved breeding and animal health to shrink the unproductive part of the herd and related emissions, use of vaccines and genetic selection methods all geared towards improving production efficiency at animal and herd levels. Most of these technologies are contained in national policy actions to achieve environmental sustainability in livestock production.

Country priorities for alignment of adaptation and mitigation would be those in which INDCs specifically target the livestock sector (adaptation, mitigation, or both), and where both mitigation and adaptation challenges are substantial. Based on the data analyses of Challenge 1 (Fig. 2) and Challenge 4 (Fig. 6), we argue that the highest priority worldwide is India. Some priority geographies appear evident in sub-Saharan Africa including Ethiopia, Kenya, Tanzania, and Nigeria, as well as in Latin America (Colombia, Mexico), and South-East Asia (Vietnam).

5. Stakeholder consultation and demand

Evidence of stakeholder demand for LCSR

Work Package	Stakeholder priorities in which country or region	Evidence Link
Systems level research and interventions	Resilience-building in drylands communities is a priority Land tenure security and good governance is vital for resilience and restoration in pastoral systems Rangeland degradation is a critical issue for extensive livestock production Participatory planning, management and governance are key to sustainable rangeland management Land based approaches to GHGe mitigation are critical Women and youth as agents of change in livestock-based systems Increasing aid budgets for drought-related crises	WB & AFD Confronting drought in Africa's drylands FAO Pastoralism in Africa's drylands FAO VGGT pastoral guidelines IFAD HTDN pastoralism USAID WA landscapes review Sahel 2DI sessions HoA 2DI sessions UNFSS Action Track 3 FAO (2021) Rationale for using participatory approaches in rangelands FAO (2021) Pastoralislm in Africa's drylands LAC 2DI session GRA discussions IFAD Women and pastoralism IFAD Gender and pastoralism HTDN FAO Youth and pastoralism Netherlands MOFA Women's empowerment in value chains EC 2019
Household level technologies	Inventories of good livestock management are needed Social inclusion and gender equity are critical to improve access to CS technologies Households need appropriate incentives to adopt mitigation practices	LAC, Sahel and HoA 2DI USAID CEADIR project and LED feasibility study IFAD and World Bank guidance 2DI listening sessions Kenya Dairy NAMA

Climate Information Services	CIS critical for adaptation in agriculture, including livestock Bundled services hold promise, including for drought risk financing, to crowd in parallel investments. Public private partnerships key for sustainable service delivery	AICCRA design work HoA and Sahel 2DI sessions IBLI IGAD regional report Comments at July 2019 IBLI IGAD regional workshop, comments about KAZNET in Kenya SDL taskforce
Finance for climate and livestock	Meat and milk private sector interest in certification for livestock products Importance of sustainable finance models for climate investment	MINERVA letter LAC 2DI sessions LAC 2DI sessions
Building enabling policy environment	Africa-wide livestock capacity for livestock in climate change negotiations, monitoring and reporting Better data can support decision making for rangeland investments Better policies to support resilient pastoralism Policy alignment needed for scaling and pooling of resources Participatory LDN monitoring is required	AGNES request for LED CoP support Kenya Dairy NAMA process All 2DI sessions Discussions with Pierre Gerber, WB and Ethiopia Oromia Dairy project Support letters from Ministries Kenya ELD Rangelands report UNEP Gap Analysis FAO & IUCN Crossing Boundaries IFAD HTDN pastoralism IBLI IGAD regional reports Comments at CCAFS supported NDC workshops LMP workshops FAO Rationale for using participatory approaches in rangelands

6. Work package structure and proposed theory of change to address the challenges

The LCSR Initiative will partner with public and private actors to develop and deliver actionable innovations that measurably help producers, businesses, and governments adapt livestock agrifood systems to climate change and reduce GHGe from livestock production (Fig. 12). Beginning with landscapes, particularly in rangelands, Work Package 1 (WP1) will help livestock producers and other local actors to improve first the governance arrangements that enable restoration practices such as integrating trees and reseeding grasslands. Improved land management will regenerate the landscapes dominated by livestock production systems (LPS), leading to offsets of GHGe, reduction of conflicts over resources, and enhanced capacity to manage climatic risk particularly in pastoral systems.

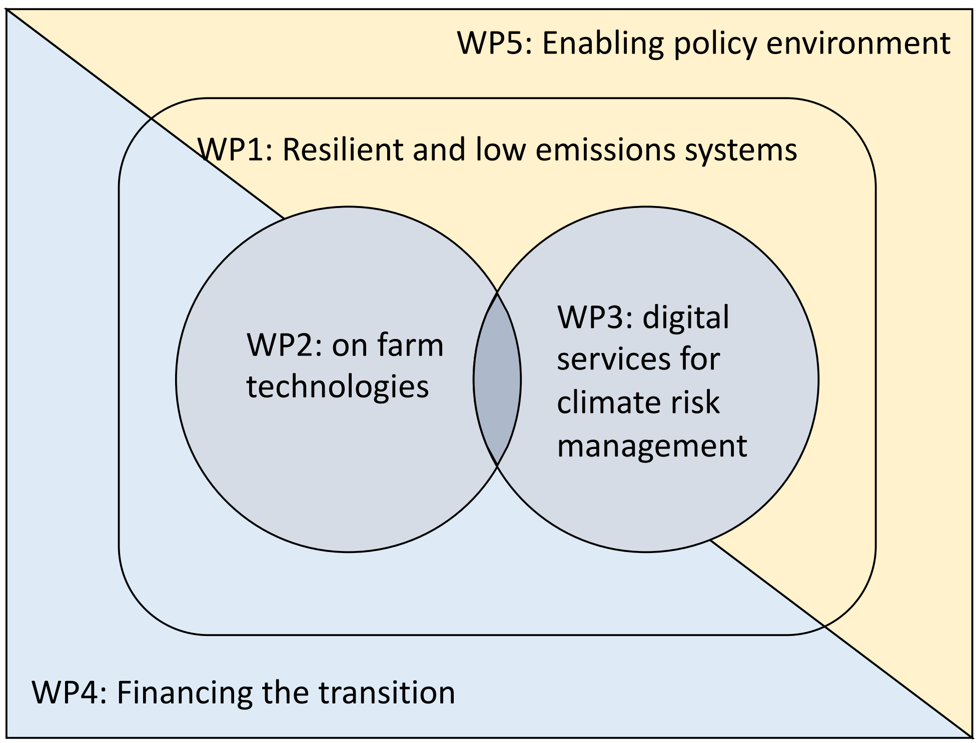

Figure 12 Livestock, Climate and System Resilience (LCSR) initiative work package structure

At the household level, WP2 and WP3 will work with livestock producers to introduce or promote promising practices and technologies to build adaptive capacity, de-risk production, and reduce GHGe. Focus on action research and on the development of scaling platforms will ensure that the practices are appropriate to the specific contexts and adopted at scale. Attention to gender and age dynamics will ensure that gender and youth-specific opportunities and constraints are identified and addressed. This leads not only to increased risk management capacity but also broad scale adoption of improved climate smart practices to further build capacity to sustain production and enhance incomes. WP3 will also specifically work to de-risk other parts of livestock value chains through increasing availability of and access to services bundles that include climate information and financial services (insurance and credit), harnessing the power of digital technologies and platforms.

Key to the success of LCSR is the ability to attract private scaling partners and enabling livestock producers to change their practices is engaging with a range of climate finance investors (WP4), while also influencing public policy (WP5). WP4 will build investor confidence in the livestock sector by better understanding their needs for investment and monitoring and improving the capacity of SMEs to absorb finance. Finally, WP5 will raise awareness about the contributions of livestock to climate targets, and will provide national partners with tools to better plan for and monitor these contributions through international reporting systems. WP5 will thus help national decision makers to improve their policies and plans to adapt and mitigate climate change in the livestock sector.

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