GASL Paper

Assessing resilience in the livestocksector - of what, to what, and for whom?

Jennifer Hodbod
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Ilse Köhler-Rollefson
Ruaraidh Petre
Brian Lindsay
Antonio Solarte
Fritz Schneider
Rogério M. Mauricio

Corresponding author: rogeriomauricio@ufsj.edu.br

GLOBAL AGENDA FOR SUSTAINABLE LIVESTOCK

WWW.LIVESTOCKDIALOGUE.ORG

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The Global Agenda for Sustainable Livestock (*www.livestockdialogue.org*) is a partnership of stakeholders committed to the sustainable development of the livestock sector. The Global Agenda builds knowledge through thematic and regional networks. There are nine action networks where members develop activities and outputs (such as reports) to provide evidence and information exchange. This paper, entitled "Assessing resilience in the livestock sector - of what, to what, and for whom?", is a result of collaboration between the Closing the Efficient Gap action network, Resilience Alliance, Michigan State University, University of Helsinki, League for Pastoral Peoples and Endogenous Livestock Development, CIPAV, Global Roundtable for Sustainable Beef, Dairy Sustainability Framework, and Bern University of Applied Sciences.

Authors

Jennifer Hodbod
Michigan State University

Pablo Manzano
Basque Centre for Climate Change & University of Helsinki

Ilse Köhler-Rollefson
League for Pastoral Peoples and Endogenous Livestock Development

Ruaraidh Petre
Global Roundtable for Sustainable Beef

Brian Lindsay
Global Dairy Platform

Antonio Solarte
Center for Research in Sustainable Agricultural Production Systems

Fritz Schneider
Bern University of Applied Sciences

Rogério M. Mauricio
Closing the Efficiency Gap and Universidade Federal de Sao Joao Del Rei

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Foreword

Given the public-good nature of the livestock sector's environmental, social and economic challenges and its increasing economic integration, collective global action is essential.

The Global Agenda for Sustainable Livestock (GASL)[1], established in 2011, is a multi-stakeholder partnership mechanism with the aim to foster and guide the sustainable development of the global livestock sector in alignment with the SDG framework of the UN Agenda 2030. It provides a platform to comprehensively address opportunities for the sector's multiple contributions towards sustainable development through facilitating global dialogue and encouraging local practice and policy change, focusing on innovation, capacity building, incentives and enabling environments.

In 2020, GASL initiated a webinar series to provide a virtual space for its technical networks to profile relevant sustainability matters. The webinar 'Assessing resilience in the livestock sector - of what, to what, and for whom?'[2] took place in February 2021, and considered multiple factors that support and challenge resilience, with a special focus on ruminants. This webinar was led by the technical network on Closing the Efficiency Gap along with the Resilience Alliance.

Two hundred and forty-seven participants from 46 countries around the world joined the webinar and represented a wide diversity of stakeholders.

Speakers introduced the concept of resilience from different disciplinary perspectives, including ecological resilience, community resilience and engineering resilience.

Panelists explored the relationships between animal health, animal production, livelihoods, climate change, and COVID-19 and the perspectives on resilience in pastoral, agropastoral, and silvopastoral systems across the beef and milk sectors. Opportunities to translate resilience theory

[1] http://www.livestockdialogue.org
[2] http://www.livestockdialogue.org/events/events/webinars/assessing-resilience-in-the-livestock-sector-of-what-to-what-and-for-whom/en/

into principles for the management of social-ecological systems, for example the case of grazing-based operations was also explored, noting that understanding the resilience of any system using the lens of resilience assessment can contribute towards strategies to cope with uncertainty and change. Such approaches must be context specific, guided by the question 'Resilience of what, to what, for whom?'

The need to take a holistic perspective using indicators that could be changed across time scales based on a participatory process with the stakeholders was also highlighted.

Challenges noted included understanding trade-offs, such as that between resilience and efficiency, or increasing diversity versus the advantages of economies of scale.

All panelists agreed that using the concept of resilience is important for livestock systems as they transition, given the need to promote social and ecological sustainability of the sector while responding to the challenges created by climate change, animal disease, or changing livelihoods and food demand.

Drawing on the rich presentations and discussions at the webinar, the paper also highlights the importance of developing a shared understanding of resilience to guide livestock sector stakeholders and decision making to foster multi-stakeholder partnerships, greater coordination and cooperation towards enhancing the resilience of the sector overall.

Those who led and contributed to this webinar must be congratulated for showcasing the important role of resilience in livestock systems towards achieving the SDGs and more sustainable food systems.

Shirley Tarawali
Chair, Global Agenda for Sustainable Livestock
2022

Webinar Summary

The COVID-19 pandemic has demonstrated both the sources and limits of livestock systems' capacity for resilience in times of crisis (GASL-2020) – the capacity to respond to change and continue developing (Folke et al. 2016). The Global Agenda for Sustainable Livestock (GASL) webinar 'Assessing resilience in the livestock sector - of what, to what, and for whom?' discussed the factors that support and challenge resilience, with a special focus on ruminants (GASL, 2021), under the leadership of the Closing the Efficiency Gap Action Network. The webinar included valuable inputs from the Resilience Alliance (***https://www.resalliance.org***). The panellists explored the relationships between animal health, animal production, livelihoods, climate change, and COVID-19. Perspectives on resilience in pastoral, agropastoral, and silvopastoral systems across the beef and milk sectors were presented (***https://www.youtube.com/watch?v=Nd4qnLq_tAA***).

Six of the seven GASL clusters were represented by the 247 participants from 46 countries around the world: academia and research (44%); donors (3%); inter-governmental & multi-lateral organizations (9%); non-governmental organizations (20%); public sector (23%); and social movements (1%). During the seminar, participants were asked to answer the following question: which is the most important outcome of the livestock sector for which resilience could be evaluated according to your stakeholder group? Five possible answers were provided: *1. Effective food value chains; 2. Long term ecological sustainability; 3. Profitability and income stability especially at farm level; 4. Healthy' rural communities; and 5. Livestock health and welfare.* The three first options were chosen by most of the participants (24.7% for each).

The concept of resilience was first introduced from different disciplinary perspectives, including ecological resilience (where resilience is neither good nor bad, rather a systems property); community resilience (more focused on adaptive capacity and resilience as a normative goal, with resilience building as a participatory process); and engineering resilience (or resistance to short- and long-term shocks or disturbances). Clearly, all the points complement each other to form a multifactorial and holistic concept, and social-ecological resilience was presented a synthesizing approach (Allen et al. 2019).

An early goal of the social-ecological resilience literature was to be translate resilience theory into principles for the management of social-ecological systems, for example grazing-based operations. Understanding the resilience of your system via resilience assessment can help with developing strategies for coping with uncertainty and change and it was advocated that this should be context specific, guided by the question 'Resilience of what, to what, for whom?' (Resilience Alliance 2010). All speakers outlined the need to assess resilience of livestock systems, across the spectrum of extensive to intensive. However, as with the debate about defining resilience, there are similar challenges in aligning resilience assessment strategies. Panellists emphasized the need to study the system you are analysing holistically, using indicators that could be changed across time scales based on a participatory process with the stakeholders. This process helps to identify errors or gaps that, after adjustments, would achieve a better balance among risks, opportunities, and knowledge to support the resilience and sustainability of the enterprise under study. Furthermore, cross-scale indicators are required for different spatial and temporal scales, for example to understand resilience of the supply chain and the farm now and in the future. But, if resilience is the overarching goal for a livestock system, indicators are required that support evaluation resilience over time.

There are challenges with understanding the resilience of livestock systems, as the panellists outline further below. One practical challenge related to resilience assessment is that a participatory and context-specific approach might limit how comparable our studies are and what we can learn across the spectrum of livestock management. So, while we don't recommend a one-size-fits-all approach to choosing indicators of resilience in livestock systems, we do see the potential for a toolbox approach, outlining a range of indicators from which an operation/system can pick those that align with their context best and support cross-system learning.

One broader point raised during the discussion given the focus on sustainability and stability was the trade-off between resilience and efficiency. As outlined below, a key principle of resilience is embedding flexibility or adaptability into the systems via a diversity of strategies to support the same function or outcome. While increasing diversity increases system resilience e.g., by providing multiple sources of feed with different tolerances for drought, it becomes challenging to then take advantage of economies of scale, which in this context may related to using monocultures and increasing input use to support higher production and efficiency. This in turn further justified the need for understand resilience – a knowledge of the interacting components, their drivers, and their impact at a system level is necessary to expose any trade-offs, including unintended consequences on system resilience.

All panellists were agreed that the concept of resilience is useful for livestock systems given the need to promote social and ecological sustainability of the sector while responding to the challenges created by climate change, animal disease, or changing livelihoods and food demand. Panellists were also agreed that there isn't a clear way to operationalize resilience in livestock systems. Therefore, the objective of this paper is to 1) define the main concepts within resilience for the livestock sector, that can be applied to both extensive and intensive systems, 2) provide case studies of resilience in existing livestock systems, and 3) outline suggestions on how to assess resilience in livestock systems. Since GASL is a partnership of multiple livestock sector stakeholders committed to the sustainable development of the sector, this paper also aims to highlight the importance of a shared understanding of resilience. A common understanding can be used to guide collaboration between GASL members, action networks and external actors to foster multi-stakeholder partnerships (MSP) coordination and cooperation and the resilience of the sector overall.

› Perspectives from the Resilience Alliance

Dr Craig Allen

Center for Resilience in Agricultural Working Landscapes, University of Nebraska – Lincoln

Agriculture, in its many forms, constitutes an enormous investment in social, economic, and political infrastructure, creating complex social-ecological systems focused on food production. Agriculture, like other facets of human society, has complexified and scaled up, and increasingly efficient approaches are exported as global solutions to achieve food security, yet the resilience and long-term sustainability of these models are uncertain and untested. The importance of agriculture to humanity demands an understanding of its response to stress, and where critical tipping points may lie— its resilience.

There is basic disagreement on how to meet human resource demands into the future. Continued intensification may eventually exceed limits and ultimately undermine the human life support systems provided by the natural environment — including agricultural production. Sustainable intensification of agriculture should be guided by an understanding of boundaries, context and resilience. There is a clear need to distinguish a safe operating space (i.e., sustainable agricultural practices at local to landscape scales) for agricultural production in order to sustain production in an era of rapid global change.

Dr Lance Gunderson
Department of Environmental Sciences, Emory University

Social-ecological resilience is an emergent property of complex social ecological systems that mediates transitions among alternative system regimes. Such regimes are defined by qualitatively different structures and processes at particular scales and by distinct ecological, social and economic variables. Often, monitored variables provide information about system state, status, and output. In many cases, transitions or sudden flips between alternative regimes have been revealed by such long-term monitoring programs. The predictability of such tipping points (often signalling a loss of resilience) is an ongoing, open question among scholars. However, even though practitioners may not be able to predict such regime shifts, they can use information from monitoring along with experience and conceptual frameworks (such as resilience thinking) to develop an understanding of system dynamics, how resilience may be eroded, when systems have crossed thresholds, and how to robustly respond.

› Introduction to resilience

Dr Jennifer Hodbod
Department of Community Sustainability, Michigan State University

> *"Resilience is more than just 'bouncing back' – it is a systems property that allows thriving systems to cope with change but also that potentially locks systems that aren't thriving into unsatisfactory regimes. An understanding of resilience in livestock systems allows us to understand what makes such systems resilient, whether the system being maintained is one that achieves a range of goals and functions, and if not, how to rebuild our systems"*
>
> ***Jennifer Hodbod***

Social-ecological resilience is a multifaceted concept - the capacity of a system to a) respond to change through adaptation or transformation while maintaining structure, function, and identity while b) supporting positive and proactive development (Walker et al. 2004, Brown 2015, Folke 2016). The first point demonstrates that there are multiple actions that indicate resilience - a system is resilient if it can adapt to maintain its identity but also if it can intentionally transform to a new identity (Folke 2016; i.e., a grazing-based operation changing their grazing management and adding in agrotourism). In contrast, an unintentional change in structure or function indicates a lack of resilience (i.e., a grazing-based operation going out of business and selling the herd). Figure 1 demonstrates the spectrum of how resilience is demonstrated (Béné et al. 2012) across agro-pastoralist systems:

- Coping strategies that support stability - reactive and short-term actions that utilize easily accessible and replaceable resources;
- Adaptive strategies that support flexibility – medium-term actions that require some planning and use more resources or those that can't be replaced as easily;
- Transformative strategies that support change – long-term, proactive actions that require significant resource use (whether financial capital, social capital, or knowledge).

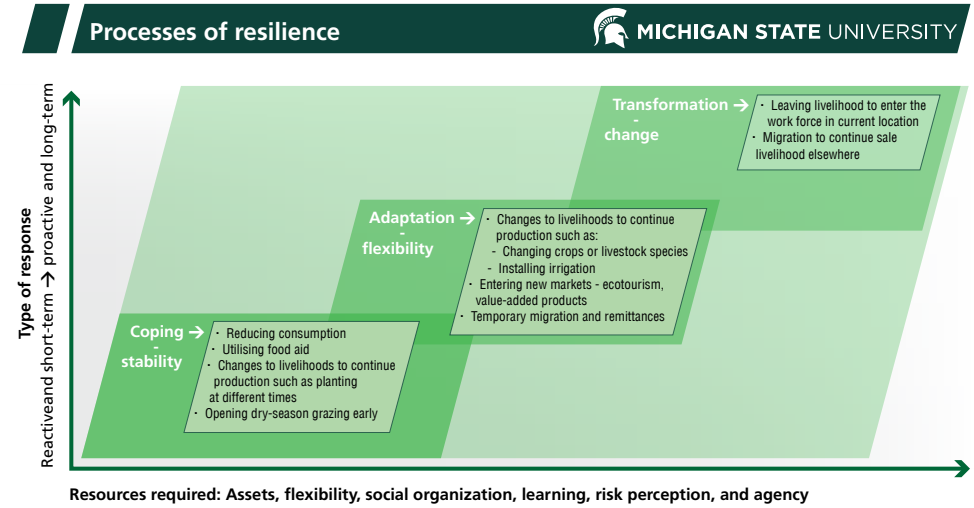

Figure 1 / There are three main processes through which resilience is demonstrated – coping, adaptation, and transformation (adapted from Béné et al. 2016).

In this framing, resilience is more than just 'bouncing back' – it is a **systems property** that, in its most desirable form, allows thriving systems to cope with change. The systems perspective blends ideas from complexity theory, ecology, and social sciences to understand dynamics of change and alternate regimes in social-ecological systems. The systems perspective of resilience is more appropriate for livestock systems than framing resilience as a **rate**, or how long it takes for a system to recover after a disturbance (i.e., bounce back, which comes from engineering). The latter implicitly suggests that we can severely degrade systems, but that they will inevitably recover, provided time is sufficient (Allen et al. 2019). We know this is not true in our social-ecological systems. As resilience ideas have gained popularity, there has been more discussion of resilience as a **process**, i.e., 'building resilience'. Caution should be used here to not always see resilience as a virtue - as a systems property, resilience can also exist in systems that do not support thriving (i.e., poverty, homelessness, desertification). Hence, the importance of transformation within resilience, which supports reconfiguring systems to 'break' resilience in systems where it is unhelpful, creating an opportunity to reorganize systems and create identities that are both resilient and sustainable. There are lessons to learn here for livestock systems – we can use resilience thinking to understand what makes our systems resilient and whether the system being maintained is one that achieves a range of goals and functions – if not supporting sustainable goals, we can use resilience theory to rebuild our systems (Hodbod & Eakin, 2015; Hodbod *et al.*, 2016).

» Seven principles of resilience

There are seven principles of resilience (Biggs *et al.* 2015). While all Biggs *et al.* (2015) present all seven principles as equally important, the webinar presented diversity as the bedrock of resilience, supporting multiple other principles as demonstrated below, while a systems perspective is required to understand how all principles fit together:

- *Maintain diversity and redundancy:* Systems that are more diverse are generally able to cope better with disturbance (e.g., a drought, a pandemic), as diversity provides redundancy and improves the likelihood that system components can compensate if others fail.
  - *Manage connectivity:* Systems that are well-connected facilitate access to new ideas, information, and resources that help to adapt to or mitigate surprises. However, highly connected systems can also spread disturbance much faster.
  - *Encourage learning:* Social-ecological systems (SES) maintain their function by building capacity to adapt. A system that encourages learning is constantly incorporating new and diverse knowledge and experiences and is therefore more prepared to adapt to disturbance than one that does not.

    - *Broaden participation:* Involving diverse actors in SES management expands the types of knowledge in a system and improves legitimacy. The more actors hold a shared understanding of, feel a part of, and benefit from the system, the more they work together to maintain it.
        - *Promote polycentric governance:* As for participation, a governance system where multiple decision-making bodies interact can enhance coordination and collective action in times of surprise and uncertainty. However, too many interacting decision-makers with different goals or values can also lead to paralysis in decision making.
- *Foster complex adaptive systems thinking:* To manage for resilience, decision-makers must understand that systems are complex and unpredictable and that one-size-fits-all solutions do not exist as different people experience ecological and social environments differently.
    - *Manage slow variables and feedbacks:* Some slowly changing variables in a system, like soil quality, can maintain or limit resilience but are often forgotten in management, which can result in an undesirable system reorganization.

The examples above outline that there is often an optimum level, rather than more is always better, and that it is also important to ground the principles in a particular context to explain the resilience outcomes. For example, if diversity is key (as it supports self-organization and learning, which underlie the processes of adaptation and transformation - the ways in which systems demonstrate resilience, as outlined in Figure 1) we need to understand the types of diversity in our livestock systems. This could be structural diversity (genotypes, linkages), input source diversity (energy, information), output diversity (ecosystem services), knowledge diversity (incorporating multiple world views and knowledge systems including indigenous and local knowledge as well as science) or diversity in governance approaches and actors. We also need to acknowledge diversity at different scales – the farm, region, climate, value chain etc. Too create resilience of desirable regimes in livestock systems, we need to find the optimum for multiple forms of diversity (in resources, in networks, as forms of knowledge, in governance) at multiple scales.

» Resilience assessment

To apply these principles to management of social-ecological systems, the Resilience Alliance (2010) recommends the overarching question – resilience of what (i.e., the system under study), to what (i.e., the shock), for whom (i.e., how the range of stakeholders is influenced)? The latter part is an important addition to earlier literature (Carpenter *et al.* 2001) that indicates that within a system there will be a diverse range of actors who experience change and resilience differently, and thus efforts should be taken understand equity implications of different change events and support resilience for the most marginalized (Lebel et al. 2006).

From the perspective of the Resilience Alliance, a resilience assessment is not looking to quantify resilience but to understand system dynamics – in fact, measuring a narrow set of indicators or reducing resilience to a single unit of measurement may block the deeper understanding of system dynamics needed to apply resilience thinking and inform management actions (Quinlan *et al.* 2016). Therefore, there is no explicit methodology for resilience assessment that can be included here, and a case study approach is used, integrating interdisciplinary and participatory perspectives adapted to the local context to as per the Resilience Alliance (2010):

1. Bound the system of interest – identify the spatial, temporal, and governance scale.
2. Describe the system i.e., the structure and function of the focal system – what are its components, how are they connected, what are the resulting outcomes?
3. Understand system dynamics i.e., how have these components and outcomes changed over time?
4. Understand interactions i.e., what are the impacts from other scales?
5. Understand system governance i.e., what institutions are playing a role (or could do so)?
6. Act on the assessment i.e., how can the findings influence the management of the system?

As the latter step indicates, resilience assessment is intended to be an analysis tool to embed in management of systems. Hence, why 'for whom' is important – the actor directing the assessment will also influence the reasoning and values behind the assessment (i.e., the 'for what'). Therefore, as outlined above, it is important to identify key indicators to track over time, through the study of which (and their change or lack of change in response to disturbance), one can explore which resilience principles are most important to explain what is supporting resilience (or not) and whether it's a desirable system identity (or not). A toolbox approach best supports the context-specific approach required for livestock systems - we can create a toolbox of types of indicators, but the choice of which to study and the specific metrics will be dependent on the specific system, its scale, and which actors are involved in the assessment and for what purpose. The case studies below outline livestock systems across the extensive-intensive spectrum and identify elements that enhance or erode resilience. From this, we can begin to identify types of indicators for GASL to integrate into a resilience assessment toolbox for livestock systems.

Case studies of resilient livestock systems

The following sections describe several case studies along an extensive-intensive spectrum of livestock systems, exploring resilience in pastoral, agropastoral, silvopastoral, beef, and dairy systems.

Resilience in pastoral systems

Pablo Manzano
Basque Centre for Climate Change & Helsinki Institute of Sustainability Science, University of Helsinki

> *"Pastoralism's resilience relies on integrating economic, social and environmental elements, and depends on their understanding to thrive. Pastoralists have managed to do so during thousands of years, but are threatened by more simplistic approaches. A better multi-disciplinary understanding will promote sustainable pastoralist livelihoods"*
>
> ***Pablo Manzano***

Pastoralism is a livestock-based livelihood system where animals feed largely on grazing natural resources thanks to their mobility and to governance agreements that allow land to be grazed by multiple herd owners over time. It is therefore capable of optimizing livestock production using bursts of plant productivity that are often short lived and unpredictable (Krätli et al. 2015). Pastoralism is the most ancient way of keeping livestock, with over 10,000 years of history. It is also the most geographically widespread livelihood on Earth, adapting to different types of climates, ecosystems grazed, animal species used and cultures adopting it (Manzano et al. 2021). Such persistence in time and space indicates a high capacity for resilience, as well as the ability to use resources in a sustainable, non-extractive way. This leads to pastoralism sustaining high biodiversity systems by mimicking the action of large wild herbivores, and avoiding land degradation, all at a very low fuel footprint – as modern fuels have only been available in a small fraction of pastoralism's existence. Its environmental and cultural values also allow pastoralist products to reach high added value if marketed correctly, with examples worldwide.

The pastoral system is a socio-ecological system, meaning that environmental and social factors are deeply entrenched in its functioning. Knowledge on the vegetation animals graze upon, monitoring of its status, and avoidance of detrimental fauna such as pests, are traditional ecological knowledge elements that pastoralists must master. But their actions are subjected

to social rules that reward good use and punish abuses, as well as economic determinants for their products. Hence, many severe problems in pastoralist areas have been interpreted through reductionistic approaches, blaming many pastoralist practices for being backward, ineffective, and non-resilient. This has failed to understand that the delicate equilibrium of environmental, social, and economic elements in pastoralist livelihoods has often been disrupted by sectorial development interventions which did not understand such complexity (Figure 2).

Social patterns

(e.g., selection of extreme physical traits such as long horns) explained through environmental-economic perspectives, such as heat dissipation.

Image: Sarah McCans/ Wikimedia Commons: Ankole_Cattle.jpg (cc-by 2.0)

Environmental patterns

(e.g., overgrazing) explained through economic perspectives, such as subventions to fodder provision.

Image: Helge Busch-Paulick (Grand-Duc)/Wikimedia Commons: Reinde-er_in_finnish_fell-2.jpg (cc-by 3.0)

Economic patterns

(e.g., production efficiency) complemented by environmental perspectives, such as delivery of ecosystem services.

Image: Dguendel/ Wikimedia Commons: Cap_Gris-Nez,_flock_ of_sheep.jpg (cc-by 4.0)

Figure 2 / Crossed effects of social, environmental, and economic patterns – usually ignored.

For such a widespread and historically important livelihood there are abundant examples of crises, recoveries, failed and successful interventions to learn from. It is, however, not straightforward to compare such culturally and geographically diverse systems, which may be the reason for widespread misunderstanding of pastoralism and lack of integrated cross-sectoral data. Manzano et al. (2021) propose an approach of analysing trajectories of pastoralist societies along time in order to identify crises, bottlenecks and critical interactions of social, economic and environmental factors. While much of the narrative concentrates on natural resources and livestock productivity, social outcomes such as the population of remote areas and the derived provision of services for travellers, or in terms of national security or exercise of sovereignty, is often ignored. Such approach requires, however, that a set of indicators is used which can be compared along different time scales. Such an indicator set must be truly transdisciplinary in nature, meaning that it must be elaborated with farmers and for farmers, thus ensuring their usefulness and farmer collaboration in programmes. It can then be used beyond interventions, to assist in structuring advocacy and encouraging exchange actions of pastoralists themselves.

Resilience in Agro-pastoral systems

Ilse Köhler-Rollefson
League for Pastoral Peoples and Endogenous Livestock Development

> *Using India as an example this paper argues that agro-pastoralism is well adapted to coping with natural shocks due to features such as mobility, traditional knowledge, social networks and well-adapted animals, but being undermined by anthropogenic activities. In order to increase the resilience of livestock keeping, we need to appreciate the ecological and economic benefits of agro-pastoralism and develop policies to support it*
>
> ***Ilse Köhler-Rollefson***

The majority of India's livestock is kept in agro-pastoral systems, meaning pastoralist communities herd their livestock - sheep, cattle, goats, camels, buffaloes, pigs - on harvested fields owned by farmers in order to make use of crop aftermath and fertilize the land with organic manure. This is a mutually beneficial arrangement that serves the needs of both farmers and pastoralists, reduces dependence on chemical fertilizer, and depends on good social relations. Agro-pastoralism comes in a variety of guises that includes transhumance and nomadic, semi-nomadic, and village-based herding (Kishore and Köhler-Rollefson, 2020). According to prevailing thinking, these systems would be classified as extensive since they involve the movement of flocks of sheep and herds of cattle, goats, buffaloes, camels, pigs, and even ducks over large areas of land. On the other hand, agro-pastoral systems must also be regarded as 'intensive', with respect to social arrangements, human labour, and management input per head of animal, which is considerable. This way of production relies on physical labour of both people and animals. People herd animals over long distances to diverse types of forage, instead of having it transported to them (Figure 3). The big advantage of the system is that it is entirely solar powered; no fossil fuels are expended. These herding systems are also knowledge intensive, and they require extensive social networks in order to obtain access to continuously shifting patchworks of privately-owned harvested fields, of so-called 'wastelands', of village commons, and of government managed forest.

Figure 2 / India's livestock in agro-pastoral systems.

Because it is both knowledge- and labour-intensive, agro-pastoralism resists simple categorization as extensive or intensive. However, its benefits are enormous as these systems that are present all over India ensure that the smallest amounts of crop waste as well as the biomass in the remotest areas are utilized and converted from waste into feed and fibre. At the same time, migratory herds deposit organic manure directly on the land, reducing or eliminating the need for chemical fertilizer.

The most important indicators for the resilience of these systems are:

1. **The ability to move and making use of variability (Krätli, 2015a).** Theoretically, this depends on the walkability and hardiness of herd animals, as well as the willingness of herders to put up with hardships. In practice, the ability to move is continuously reduced due to fencing of land, urban sprawl, closing of forest areas for conservation, and construction of highways on ancient migration routes. These developments very much undercut resilience or even the feasibility of agro-pastoralism.
2. **Healthy animals and good reproductive/survival rates.** The animals and breeds kept in agro-pastoral systems have been selected for hardiness and resilience for centuries, and herders constantly experiment with introducing new genes to see if they can further improve 'performance' under harsh conditions or when there is need for adapting to changing market conditions. Yet, disease outbreaks occur regularly, and reproductive rates fluctuate significantly from year to year. The ability for the herd size to cope with such changes and for herd size to increase back to prior levels in good years is a very important indicator of resilience.
3. **Existence of social ties with farmers and other stakeholders.** Good relations and social compacts, often going back over generations, are essential for enabling movement and access to forage. When farmer-owned land suddenly changes ownership, the social ties vanish, and it becomes difficult or impossible to continue moving.

4. **Leadership.** Herders usually move in groups of several families to help each other out and to present a stronger front against livestock thieves, which pose a significant danger. To have a good leader who makes the right decisions, maintains harmony in the group, and knows how to interact with other stakeholders is crucial for successful migration. Without dedicated herders and capable leadership, migration is doomed.
5. **Supportive officials and acknowledgment of grazing/customary rights.** There is a distinct variance between states, especially their forest departments, in their attitudes towards pastoralists. This can make all the difference between continuation and abandonment of agro-pastoralism.

Indian agro-pastoral systems are extremely productive, contributing more than 70% of the nation's meat and 50% of its milk (Kishore and Köhler-Rollefson, 2020). India is also the world's largest dairy producer and the biggest exporter of sheep/goat meat and first or second in beef exports. The enormous output is generated largely without fossil fuels and especially grown feed, while contributing enormous amounts of organic fertilizer that saves the nation huge amounts of chemical fertilizer.

However, these benefits remain officially unacknowledged, as the focus of animal scientists is on individual animal performance under controlled conditions (Köhler-Rollefson, 2020). There is a general sentiment that Indian cows cannot compare in milk yield with cross-bred or exotic ones and that the growth rates of local sheep breeds do not compare with those in foreign countries. However, such a perspective ignores how local species are adapted to the environmental context, which allows continued productivity over time, even if at a lower rate. There is no realization that agro-pastoralism works according to different principles than stall-fed systems in which animals are input-output converters for feed that is brought to them, which requires using human-stored energy resources. In agro-pastoral systems, animals walk to diverse types of forage, acting as aggregators of the solar energy captured by plants. It is a perfect example of nature-positive production.

» Improving the resilience of small cattle ranchers in the Andean-Amazon piedmont of Caquetá, Colombia[1]

Antonio Solarte
CIPAV, Colombia

> *"Resilient livestock farmers are those who are well aware of their climate risks and who develop and implement adaptation measures to address these challenges"*
>
> ***Antonio Solarte***

In Colombia, cattle ranching contributes 1.4% of the National GDP (21.8% of the agricultural sector), generates 1.1 million jobs, and occupies an area of 22.9 million hectares in pastures for a population of 28.8 million head of cattle (FEDEGAN 2021). The Department of Caquetá is partially located in the Andean-Amazon piedmont. The main economic activity is cattle ranching with a herd of 2.160.420 dual-purpose heads of cattle, that generates the livelihoods of 22.000 families through the sale of milk and cheese (Torrijos 2020).

According to the Instituto de Hidrología, Meteorología y Estudios Ambientales - IDEAM (2018), cattle ranching in the Amazon is one of the main drivers of deforestation, where slash-and-burn is predominant for the establishment of pastures for extensive cattle ranching systems. This generates impacts on biodiversity and diverse ecosystem services such as soil degradation, in addition to greenhouse gas (GHG) emissions. It is estimated that climate change will have negative impacts on Colombian cattle ranching with losses in milk

[1] This case study is based on the progress of the Project: "Resilient food production in horticultural-livestock systems of Family Farming in climatically vulnerable regions of Argentina and Colombia" funded by Euroclima+. Resilient Food Production Component (2021-2022).

and meat production of up to 7.6% and 2.2%, respectively, with Caquetá being one of the affected regions (Tapasco et al. 2015). An increase in temperature of 2 °C is expected for this region, as well as an increase in rainfall in the piedmont region and a decrease in the Amazon plain.

In Caquetá, the livelihoods of ranching families will be affected by climate changes, which may lead to further land-use change and consequently deforestation for new areas for cattle ranching. In addition to strategies and policies to curb deforestation, climate risk analysis and knowledge must be developed to enable these communities to identify and implement adaptation measures that will improve their resilience.

We followed the concept and methodology of climate risk (GIZ and EURAC 2017) proposed by the Intergovernmental Panel on Climate Change (IPCC AR5) to co-design adaptation measures, based on participatory workshops with farmers in Caquetá. Following this approach, technicians and producer families analyse the basic concepts of climate change and identify the main threats that lead to negative impacts on their systems (e.g., family farming, livestock, crops), according to their knowledge and perception of climate trends. They also identify the interrelationships between climate threats, exposures, sensitivity, and adaptive capacity to find possible responses as adaptation measures (Tallarico et al., 2021).

The three identified climate hazards that affect the grazing systems were related to increases in temperature, periods of increased precipitation, and periods of decreased precipitation. A total of 39 adaptation measures were identified. These included: strategic farm planning; conservation and sustainable use of resources such as water and soils (as shown in Figure 4); improving food security; planning and use of pastures and fodder conservation; genetic improvement and livestock welfare; strengthening of community organization; training; and technical assistance. The approach allowed the development and dissemination of these adaptation measures on established pilot farms and through the development of field schools, which integrate the community in periodic meetings where specific topics related to each measure are discussed.

Figure 4 Silvopastoral system in Caquetá, Colombia. The system is based on sustainable agro-ecological intensification, including the conservation and restoration of forests, wetlands, and water sources; it includes the division of paddocks with multipurpose trees and crops for food security in strips and a livestock water system to avoid environmental degradation.

Considering resilience at multiple scales in the beef sector

Ruaraidh Petre
Executive Director, Global Roundtable for Sustainable Beef

> *This section considers the interconnected nature of approaches to improve resilience, starting with soil and the considerable impact that building soil organic carbon can have. At the level of the farm or pastoral enterprise these approaches contribute to economic and social resilience, while at ecosystem / landscape level we see benefits in terms of adaptation and mitigation of climate change as well as biodiversity. Improvements to resilience of value chains are needed to minimize negative impacts on consumers in the face of disruptions. Finally, the complementarity between components of the food system need to be recognized to enhance circularity and resilience*
>
> ***Ruaraidh Petre***

There are multiple aspects of the food production system that should be considered for resilience at different scales:

Soil

Resilience of farming systems starts with the soil. Soil health, soil conservation and indeed soil building must become a cornerstone of sustainable production systems.

"Sequestration of carbon in soil, both soil organic carbon (SOC) and soil inorganic carbon (SIC) is strongly determined by management-induced differences in soil physical, mechanical, strength, and hydrological properties. These properties affect SOC sequestration through creation of either a positive or negative soil/ecosystem carbon budget. A positive SOC budget positively affects agronomic productivity and above and below ground biomass, and thus, is a sink for atmospheric carbon dioxide (CO_2) and methane (CH_4)." Lal (2021).

It has long been recognised that good management can increase soil carbon sequestration, and this is the largest potential we have for taking carbon out of the atmosphere. For that reason alone, managing for sequestration should be a top priority. However, as referenced above, a positive SOC budget positively affects agronomic productivity, and therefore contributes to producing more food with a lower footprint. Furthermore, increased SOC contributes to increased soil N and water retention, and therefore greater resilience in the face of changing climate (Mosier et al. 2021). Management of grazing regimes has a dramatic impact on soil health and should be regarded as a relatively low technology, high potential mitigation and adaptation measure for food system resilience (ibid).

Farm / pastoral business or livelihood

As outlined above, resilience covers a number of aspects: "The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain the same function, structure and identity" (Walker et al. 2004). On a farm or within a business, our understanding of the system must include all of the traditional pillars of sustainability – environmental, social, and economic. The fact that planned adaptive grazing systems (as shown in Figure 5) contribute to outcomes that help in both adaptation to and mitigation of climate change as well as enhancing biodiversity leads to the conclusion that they can also contribute to economic and social dimensions of sustainability as well, even if they are not necessarily maximizing yield per unit area (Rowntree et al. 2020). The trade-off between supply and demand and differential pricing will influence producer's choice to embrace such production models.

Figure 5 / Adaptive Multi Paddock (AMP) Grazing can increase carbon flows and offtake, increasing resilience through mitigation and adaptation to climate change. Lees Valley, NZ

››› *Ecosystem / Landscape*

Grazing lands occupy around 2/3 of the land we use to produce food, and cover very extensive, biodiverse ecosystems and landscapes. The livestock sector has a responsibility to protect that biodiversity and enhance it where possible. As it happens, measures designed to increase resilience and adapt to climate change may also favourably benefit biodiversity in agro-ecosystems, as well as assisting in mitigating climate change: “They’re not really about carbon farming, even though that’s an outcome… They have a focus on rebuilding resilience into the landscape and with that comes productivity” (Gosnell et al. 2020).

››› *Value Chain*

A resilient value chain needs to be able to adapt to shocks in both demand and supply). 2020 sorely tested the resilience of meat supply chains, which faced multiple shocks both as a result of African swine flu (ASF) outbreaks, particularly in China, and the human Covid-19 pandemic. What both diseases demonstrated was that shocks at this scale have a very disruptive effect on meat supply that can impact negatively on both producers and consumers. While value chains can be efficient when there are no disruptions, 2020 showed they are poorly adapted to cope with such large human or animal disease outbreaks. The concerns of those who buy and consume livestock products have come to the fore: the fact that the spend on meat in the US during the pandemic increased by 13.3 billion USD is testament to the fact that shortcomings of the system dramatically impacted on consumer prices, and the fact that consumers were willing to spend that extra money to ensure their own nutrition. Consumers are more than ever concerned with nutritional value, safety, sustainability, and transparency of the products they buy.

››› *“Food System” – particularly the interactions between food / feed / livestock / crops*

In discussions of the food system, it is often implicitly assumed that food sources are entirely fungible – that for example we eat meat for the calorie content, or that all protein sources are equal in value. It is sometimes also assumed that large changes in one commodity will have no impact in others (e.g., that less meat production will not affect grain production). Since farming systems are all interconnected, we know that a large change in one area, e.g., livestock production, will always impact on others. Livestock manure (left on the pasture and stored/applied to soil) currently supplies approximately the same amount as provided by synthetic fertilizer (FAO 2015), which as mentioned above is essential to maintenance and increase of SOC.

Livestock feed sources are overwhelmingly (86%; Mottet et al. 2017) inedible to people. So while livestock are certainly large consumers of crop products, they pay that back by upcycling large amounts of crop by products and inedible roughage for grazing lands that cannot grow crops and returning manure to grow crops. Without that upcycling and recycling role, we would have much less land to produce human food from, and while animal sourced proteins are complete in amino acids in our diet, many plant proteins are not, so our protein consumption would be further compromised.

A resilient food system makes use of the complementarity between its component parts and resources to achieve efficiency.

» Resilience in Dairy Farming

Brian Lindsay
Director of the Dairy Sustainability Framework and the Global Sector Lead for Sustainability with Global Dairy Platform

> *"When building resilience in the farming business it is important to appreciate the 'system' and its many 'sub-systems' including their interrelationships, to ensure that strategy is comprehensive and effective and does not inadvertently result in unintended (negative) consequences. Getting the balance right for your unique set of circumstances is critical"*
>
> ***Brian Lindsay***

Like all agricultural food production, dairy farming is a business; all businesses need to be resilient. The challenge that dairy farming has is that resilience needs to cover a multitude of different aspects of this dynamic biological production system. Complexity, combined with the diverse nature of the dairy farming systems globally, explains why there is no one resilience model that can be applied to all. FAO statistics show that there are approximately 133 million dairy farms globally. Each of these will have a unique set of characteristics covering geography, size, genetic potential, market, financial status and human resource availability, knowledge, and skills, etc. It is the effective combination of these and other system components that will ensure the resilience of the system.

Farmers tend to be practical individuals. Sitting at a desk, considering their short-, medium-, or long-term strategies isn't always high on their list of priorities. Having said that, the vast majority of farmers will have ideas and concepts in their heads that, when combined, evolve into a form of strategy. Generally, farmers are excellent forward planners, be it in establishing grazing plans, setting breeding goals and programs etc. So how can we bring that skill into resilience planning? Critically it is the morphing of these skills and ideas while introducing the concept of resilience in planning that will make all the difference.

To most farmers, resilience will be understood to be a risk mitigation exercise. Farmers today will inform you of changes in the climate or how difficult it is to find good labour. Therefore, they develop strategies that adapt to the changing climate or limitations of skilled labour as critical to their future success. Success to many will be evaluated via some form of economic measure, though not always. It is important farmers appreciate there is so much more to consider when building resilience into their strategies.

Though the dairy farm system is complex this can also be a benefit when considering resilience. There are so many components in the farming systems of livestock production that provide opportunities to establish resilience and spread the risk. For example, in some parts of the world livestock are used as an insurance policy against crop failure. Beyond this and considering the circular economy, livestock are critical to achieving the desired output of a sustainable and resilient food system. The challenge is how we place all the pieces of

the dairy farming jigsaw together to develop that final 'resilience picture' for the individual business. For example:

- **India** Manure from cattle is collected and used for fertilizer on farmers' own land, sold to other farmers as fertilizer or sold as fuel to the general public. Livestock also provide the much necessary draught power to cultivate the lands of small-scale farmers.
- **UK** Some dairy farmers provide manure for crop farmers to reduce their synthetic fertilizer input. Sometimes these crop farmers grow the forage for the dairy farms' winter rations.
- **USA** Farmers have manure digesters to generate 'green fuel' for use on the farm or provide energy back to the 'grid'. The digestate from the digestion process is extremely valuable organic fertilizer.

There is the opportunity for dairy farmers to identify the right model for their unique circumstances while considering the three pillars of sustainability – economic, social and environment. This will involve not only considering the production system alone but external aspects such as market potential (for a range of 'goods'), climate, legislative requirements, capital, and labour. Taking a systems approach enables the business to look at the many interrelated sub-systems and identify where potential resilience related opportunities and challenges sit. Addressing these and being conscious of the interrelated impacts and trade-offs at a sub-system level will ensure when appreciating the business at the 'system level', the chance of unintended negative consequences will be limited. In addition, at a sub-system level, there is considerable potential for identifying added opportunities and benefits. For example, increasing grassland productivity per hectare will involve improved soil management and give rise to potential carbon sequestration opportunities if the right interventions are applied. Improved soil management improves the resilience of the farming system in multiple ways from moisture retention to productivity.

Technology development for agriculture is moving at a considerable pace (Figure 6)! Whilst the dairy community is hungry to adopt new technology to improve the business management and husbandry of the animals under their care, developers need to ensure technological developments are accessible to all farmers. FAO research has found that the majority of the world's food production is from family farms and with respect to the dairy sector, farms with more than 100 cows globally represent 0.3% of total dairy herds (FAO 2016). To build resilience aided by technology in the global dairy farming sector, technology needs to be accessible.

Figure 6 / Individual animal management with the aid of mobile phone and transponder technology

The opportunities for dairy farm resilience are many and in marketing terms, it is about getting the right 'product mix' or getting the 'balance right' for the individual business.

Do farmers:

- Consider what they really want for the future?
- Focus on maximizing their milk supply contract value?
- Use sexed semen and produce an increased quantity of beef?
- Sell heifers or rear heifers for others?
- Engage in partnership arrangements with other complimentary farming businesses?
- Consider the most effective use of their land?
- Market manure/compost or digestate
- Adopt technology?
- Outsource certain tasks?
- Consider what is most profitable – e.g., does size really matter or is diversification an option?
- Look at utilizing their assets better?
- Focus on the needs of future generations that will succeed them?
- Do a combination of some or all of the above?

These are just a few examples of what may be possible to spread risk and ensure resilience in the dairy farming system. By taking a holistic approach, stepping back and looking at the business and the environment in which it operates (in its widest sense) through a resilience lens will be critical in taking that step to the future success of the dairy farming enterprise. Time invested in planning a resilient farming business is a better and more profitable time investment than 'getting on with just the farming'...it also generates considerably less sweat!

The operationalization of resilience in livestock systems

To be able to assess resilience requires monitoring certain key indicators (including relationships) and their behaviour over time, as well as variables that influence the capacity to respond to change in these indicators. The system-specific indicators can be created for the livestock systems as a whole, but will also need to be context-specific for different scales and geographies. The above case studies begin to provide some ideas for indicators that are of use for specific types of livestock system, specific scales, or cross-cutting indicators, as synthesised in Table 1. As a first attempt at synthesising across scales and livestock systems informed by the case studies given by the speakers, we do not pose this as a complete list but as the starting point for GASL to develop a toolbox of indicators from. Table 1 shows that the ecosystem indicators are In particular, a stronger focus on institutional indicators is needed to understand what social structures are keeping the current system in place and may need to be changed if the system is to move to being more resilient and delivering functions that allow social license.

		Intensive – extensive spectrum				
		Pastoralist	***Agropastoralist***	***Silvopasture***	***Beef***	***Dairy***
Scale	**Ecosystem**	Structure – key abiotic and biotic components (biodiversity, including herd species)				
		Function – key ecosystem services				
		Soil health (including soil carbon, soil nitrogen, water retention)				
		Land degradation				
	Operator and operation	Herd size				
		World view and mental models of livestock systems				
		Producer quality of life				
		Access to social services (education, healthcare, finance)				
		Mobility		Yield		
		Cultural value		Profitability		
		Social networks and social ties				
		Acknowledgement of customary rights				
		Productivity – meat and milk				
		Reproductive/survival rates			Consumer values	
	Value chain	Contribution to GDP				
		Payment for ecosystem services				
		Access to markets				
		Short local value chains		Capital value	Partnership agreements	
		Independence from commercial inputs		Input needs	Technology adoption	

Table 1 / Table 1. Potential indicators of resilience that could apply across livestock systems – all are intended to be looked at in a longitudinal manner, i.e., their change over time.

These indicators, along with others appropriate for the context, can then be used as indicators of adaptive and transformative capacity. Determinants of adaptive capacity include forms of capital (human, social, political, financial) as well as material resources and infrastructure, information and technology, and institutions and entitlements (Eakin & Lemos 2006). Determinants of transformative capacity include attachment to place, attachment to occupation, risk perception (Marshall et al. 2012). The above table lists multiple forms of capital that can be used to explain adaptive capacity, but additional data collection would be required for the other determinants and those of transformative capacity questions, in addition to data on the frequency and types of disturbances and the strategies employed to deal with these shocks. With such a dataset, managers could look at the above indicators to understand what assets and networks a livestock system is utilizing to maintain its output and identity (i.e., resilience through adaptation) or to intentionally change before being disturbed (i.e., resilience through transformation).

Additionally, to support an understanding of what resilience principles are supporting these adaptive and/or transformative capacities, or blocking them, indicators can be arranged by principle, as shown in Table 2. Outlining the identity of the current system is required first, including whether it is a regime to maintain (i.e., desirable and that coping/adaptive capacity should be strengthened or undesirable and transformative capacity should be strengthened). Then, the analysis of which principles are supporting or blocking resilience can assist in highlighting where to focus efforts to strengthen resilience of livestock systems that support ecological and social goals.

	Intensive – extensive spectrum				
	Pastoralist	***Agropastoralist***	***Silvopasture***	***Beef***	***Dairy***
Maintain Diversity and Redundancy	Structure – key abiotic and biotic components (biodiversity)				
	Mobility				
	Cultural value			Consumer values	
Manage Connectivity	Access to markets				
	Access to social services (education, healthcare, finance)				
	Social networks and social ties				Partnership agreements
	Independence from commercial inputs		Input needs	Technology adoption	
	Length of value chains				
Encourage Learning	World view and mental models of livestock systems				
	Access to social services (education, healthcare, finance)				
	Social networks and social ties				
Broaden Participation (including Promote Polycentric Governance)	Acknowledgement of customary rights		Decision making structure on farm		
	Governance structure at landscape scale		Governance structure at value chain scale		
Broaden Participation (including Promote Polycentric Governance)	Soil health interactions				
	Change in ecosystem services over time				
	Change in quality of life over time				

Table 2 / Potential indicators of resilience that could apply across livestock systems, arranged by resilience principle.

There are some obvious constraints to assessing resilience – monitoring diverse indicators requires time and resources, particularly cross cutting indicators across time, geographic systems, and disciplines. Therefore, it is important to define methodologies now based on key indicators so we can begin consistent monitoring across the global system and will be able to assess resilience at different scales in the livestock sector. Additionally, anticipation is required to monitor slow variables that may not seem important now, but that may cross a threshold and suddenly be significant (i.e., consumer values, soil health).

Currently, the data we have is based on yield and productivity, mostly in the more intensive systems. This reflects the focus in our global systems on efficiency and that most monitoring attention is given to documenting productivity and profit – the functions seemingly most valued in our increasingly industrialized systems (Hodbod & Eakin 2015). However, efficiency requires reducing redundancy and thus diversity to take advantage of economies of scale – as we see above, this erodes one of the core principles of resilience. During the COVID-19 crisis we have seen that the most efficient systems are also the most vulnerable (e.g., North American meat value chains were vulnerable to closure of processing plants), and that the systems that are regarded as least efficient are the most resilient (e.g., agro-pastoralist and pastoralist systems with autonomy). Therefore, measuring redundancy/diversity is an important step within operationalizing resilience thinking and practice in our livestock systems, which could be further explored using 'sensitivity to shock' analyses within models.

Focusing on indicators related to efficiency (whether as yield or GHG emissions per unit of product) ignores other dimensions of sustainability and resilience of our livestock systems,

such as ecosystem services, rural livelihoods, and antimicrobial resistance. To increase sustainability, the livestock sector has regarded closing the efficiency gap as the strategy of choice, but it creates trade-offs with resilience. Therefore, the big question the sector needs to address is how to balance the two – increasing resilience will likely mean an improved suite of ecosystem services but accepting reduced livestock product output, while increased efficiency and product output will likely make livestock systems more vulnerable to shocks, increasing the risk of their collapse. An important step is to operationalize resilience within this framing to ensure that interactions between resilience and efficiency can be assessed, and thus monitor a broader range of indicators appropriate to the context.

› Further actions for GASL

Fritz Schneider
Bern University of Applied Sciences, Livestock System Consultant, Switzerland

The synthesis in this paper demonstrates the importance of assessing resilience and offers some principles for doing so, along with multiple case studies demonstrating where resilience is being both supported and eroded in livestock systems.

GASL, its structure, its rules and procedures, its vision and objectives are a fertile ground for action towards sustainable, efficient, and resilient livestock production systems, livestock related value chains and the sustainable consumption of livestock-based food.

Extensive and intensive livestock production systems need to look at resilience in different ways: There will be trade-offs between efficiency and resilience. GASL can contribute to find a balance and develop equilibriums between efficiency and resilience in various defined livestock production systems, livestock-based value chains and livestock's role in various food systems.

Looking at the impact of COVID-19 on the livestock-based value chains it becomes obvious that decentralized and mixed crop-livestock systems have been a lot more resilient to the shocks than highly centralized and specialized systems.

GASL in its next Action Plan (2022 – 2024) needs to address the dimension of resilience explicitly. The Theory of Change will need to be adapted accordingly. Resilience will have to become an important part of sustainability and will be important for all GASL Action Networks and Clusters. In particular, the GASL Action Network "Closing the Efficiency Gap" can play an important role by developing and adding resilience indicators to the efficiency matrix. Resilience indicators as part of the efficiency matrix will improve the accuracy of the sustainability assessments of livestock systems.

During the new Action Plan period (2022 – 2024) GASL has the potential to focus on the relationship and trade-offs between efficiency and resilience. Looking at the results of the virtual GASL MSP 2021 the following way forward is proposed:

- New actions – globally and locally - new connections: GASL needs to reach out to more stakeholder groups from the society (consumers, social scientists, journalists, human health)
- Communicate livestock multi-functionality and roles in a balanced / nuanced way: address negative sides and highlight positive elements.
- Acknowledge the diversity and complexity of systems: no-fit-for all solutions.
- Strong call for coordinated action within and outside GASL.
- Communicate evidence & good practices through publications, seminars (e.g., seminar on resilience, rational use of antibiotics, etc.). Support mainstreaming evidence-based solutions, etc.

Conclusion

To understand resilience in our livestock systems requires:

a. Understanding that each system is unique to some extent and understanding it's specific context (i.e., resilience of what);
b. Understanding the shocks that a system is facing (i.e., resilience to what);
c. Understanding who the stakeholders are in the system and how they are affected by shocks differently (i.e., resilience for whom).

Tables 1 and 2 offers a first suggestion for indicators, which can be used to inform a resilience assessment of a livestock system, depending on where it is along the intensive-extensive spectrum and what scale of the supply chain. While all resilience assessments require adapting to the specific context, this will support a common understanding of the resilience of diverse livestock systems throughout the world.

What are the next steps that the CEG AN and GASL should take in this topic?

1. Having defined the main concepts of resilience for both intensive and extensive livestock sectors, explore how processes of intensification and extensification are influencing sustainability and resilience.
2. Build partnerships with more institutions and actors actively researching or operationalizing resilience in livestock sectors.
3. Use new and existing partnerships to deepen present case studies by studying them through a resilience lens while adding case studies from more diverse livestock systems to explore resilience from a perspective with both depth and breadth. I.e., add in case studies from MSU's existing work in Ethiopia.
4. Improve the table of indicators building on the more diverse case studies, to allow CEG an.

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The Global Agenda for Sustainable Livestock (*www.livestockdialogue.org*) is a partnership of stakeholders committed to the sustainable development of the livestock sector. The Global Agenda builds knowledge through thematic and regional networks. There are nine action networks where members develop activities and outputs (such as reports) to provide evidence and information exchange. This paper, entitled "Assessing resilience in the livestock sector - of what, to what, and for whom?", is a result of collaboration between the Closing the Efficient Gap action network, Resilience Alliance, Michigan State University, University of Helsinki, League for Pastoral Peoples and Endogenous Livestock Development, CIPAV, Global Roundtable for Sustainable Beef, Dairy Sustainability Framework, and Bern University of Applied Sciences.

Authors:

Jennifer Hodbod
Michigan State University

Pablo Manzano
Basque Centre for Climate Change & University of Helsinki

Ilse Köhler-Rollefson
League for Pastoral Peoples and Endogenous Livestock Development

Ruaraidh Petre
Global Roundtable for Sustainable Beef

Brian Lindsay
Global Dairy Platform

Antonio Solarte
Center for Research in Sustainable Agricultural Production Systems

Fritz Schneider
Bern University of Applied Sciences

Rogério M. Mauricio
Closing the Efficiency Gap and Universidade Federal de Sao Joao Del Rei

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