RESEARCH PROGRAM ON Livestock

CGIAR

More meat milk and eggs by and for the poor

POLICY BRIEF

MAZIWA ZAIDI

Policy Actions for Climate Smart Dairy Development in Tanzania

Maziwa Zaidi
More Milk in Tanzania

Key Messages

- Livestock generates **multifaceted economic and cultural benefits** in Tanzania – close to half of Tanzania's population depends on livestock, and 70% of milk and meat is produced in mixed crop-livestock systems.
- Maziwa Zaidi (More Milk) is needed - **the demand for milk is projected to increase by 77% over five years** from the current average per capita consumption of 45 l. The necessary rise in dairy production presents a substantial economic opportunity for smallholder farmers but also implicates potential challenges to ensure its environmental sustainability.
- **Livestock systems are the main contributor to agricultural greenhouse gas (GHG) emissions** and key drivers of global environmental degradation globally - in Tanzania, the agricultural sector is the second-largest contributor to national GHG emissions, with enteric fermentation and manure being main sources;
- Research shows **combined intervention packages** including improved animal genetics, feed, and animal health **can deliver synergetic outcomes between higher incomes and lower greenhouse gas emission intensities** – up to 140% increase in farm-level productivity and 50% in greenhouse gas emission intensities;
- **Improved dairy feeding and forages are key entry points, offering win-wins between economics and the environment**; improved tropical forages can deliver multiple benefits, from boosting incomes to climate change mitigation and soil protection co-benefits, and positive impacts on food productivity if associated with crops;
- Despite its potential to deliver win-win solutions for climate-smart dairy development, the **uptake of improved forages remains relatively low in Tanzania and requires concerted action by stakeholders**.

Policy Options

- Foster **cross-sectoral policy cooperation** at local and national levels between various ministries working at the livestock-environment nexus to strengthen the role of livestock as solution within climate smart agriculture.
- Invest in **training, extension and knowledge dissemination** to increase capacities in and adoption of improved feed and forage management and use.
- Bolster **participatory research** to develop, target and tailor context-specific practices and technologies to heterogenous smallholder farming landscape across Tanzania, and invest in the **science-policy interface** to support evidence-based decision making
- Attract **accelerated investment** from diversified donors to scale up climate-smart dairy development across the country, and **de-risk private-sector investments** in climate-smart dairy development using funds from public and non-governmental organizations.
- Promote and raise **public awareness** of the relationship between environmental issues and dairy production, and the potential of win-win solutions.

Frank Chade, a dairy hand at work at the home of Abel Mwandemange, feeds cows with "brewers waste" in the village of Ilemi outside of Mbeya, Tanzania. The "brewers waste" is mixed with supplements that are fed to the cows and Mr Mwandemange has said that he has noticed an improvement in the quality and yields of milk ©Photo K. Dhanji/ILRI

BACKGROUND

In Tanzania, agriculture employs about 75% of the total labour force and contributes one-third of the country's agricultural gross domestic product (GDP), and in turn about one-third of this GDP stems from the dairy sector. The livestock sector is a source of livelihoods and provides food, income, and employment for many millions of people in Tanzania (Notenbaert et al., 2020). Dairy farming, as a subsector of the livestock industry in Tanzania, offers multifaceted benefits in close integration with crop production: human food and nutrition, employment creation, improvement of household incomes, provision of draught power, and nutrient cycling through manure (Mwema et al., 2021). Livestock and livestock products are essential in Tanzania, and this country is home to a vibrant smallholder dairy sector.

Although the Tanzanian livestock sector is expanding, the rate of growth does not match the increased demand for livestock products. Low livestock productivity is one of the principal reasons why domestic production is unable to meet this demand. To contribute towards the achievement of the Tanzania Development Vision (TDV, 2025) and the Agricultural Sector Development Program (ASDP) II, the government, led by the Ministry of Livestock and Fisheries (MLF), launched the Tanzania livestock master plan (LMP) in 2017 to address all the challenges faced by the sector and its sub-sectors (Michael et al., 2018). The LMP pays special attention to the development of the dairy sector. The annual domestic milk production of 1.8 million litres is estimated to meet only about two-thirds of the milk demand. This supply gap is projected to keep widening as the population increases and climate change continues to impact the sector. However, the income and employment that could be generated by affordable local dairy production, processing, and marketing to fulfil this unmet milk demand present an important opportunity for improving the welfare of producers and their market agents (Notenbaert et al., 2020). Such an opportunity can also mitigate the urgent negative socio-economic effects of COVID-19, since the pandemic is expected to cut GDP growth at least in half and exacerbate poverty (World Bank Group, 2020).

Despite the opportunities and benefits that increased dairy production could bring to Tanzania, livestock systems are also widely recognized as key drivers of global environmental degradation, including increased nutrient loads, greenhouse gas (GHG) emissions, water use, grassland degradation, and land-use conversion. Thus, the predicted higher demand for dairy products poses a danger that the necessary rise in livestock production could become environmentally unsustainable. Efforts to maximize milk yields, production, and profitability could be balanced with long-term sustainability and environmental stewardship, presenting a unique window of opportunity to develop climate-smart dairy production systems (Notenbaert et al., 2020).

In response, the Tanzanian government has undertaken several initiatives including national policies, strategies, and plans; some of the most important include the

following: the Tanzania Development Vision (2025), the Livestock Policy (2006 - although this has never been officially launched as government document), the National Environmental Policy (1997), the Agriculture Policy (2013), the National Climate Change Strategy (2012), and the Land Policy (1995). The government has an ambitious plan for the livestock sector, as spelled out in the one of the TDV's 2025 goals:

> *"By year 2025 there should be a livestock sector, which to a large extent shall be commercially run, modern and sustainable, using improved and highly productive livestock to ensure food security, improved income for households and the nation while conserving the environment" (Livestock Master Plan, 2018).*

The Vice President's Office has been coordinating the review of the first ***National Environment Policy of 1997***. However, despite implementation of this policy, the six identified challenges continue to persist, and new hurdles with significant impacts on the prosperity of the country have emerged, calling for attention. These difficulties include the proliferation of invasive alien species, accumulation of electrical and electronic equipment wastes (e-wastes), introduction and production of genetically modified organisms, pollution resulting from oil and gas exploration and production, chemicals management, and impacts of climate change. These challenges persist for a variety of reasons: for example, a lack of comprehensive policy guidance, inadequate awareness, insufficient advancement of science and technology, and population growth.

Furthermore, the government has also been reviewing the ***National Climate Change Strategy*** (2012) whose overall objective is to enhance Tanzania's technical, institutional, and individual capacity to address climate change challenges. This review process offers an opportunity to integrate the following strategic interventions to promote sustainable smallholder dairy farming: enhancing the development of livestock infrastructures and services, acquiring appropriate technologies for climate-smart livestock production systems, promoting livelihood diversification of livestock keepers, advancing the development of livestock insurance schemes, and encouraging integrated rangeland management for livestock.

In addition, the government is implementing various pilot projects, such as the 'Reversing Land Degradation Trends and Increasing Food Security in Degraded Ecosystems of Semi-Arid Areas of Tanzania' project or the 'Institutional Support for Climate and Seasonal Weather Information for Adaptation Planning in Northern Tanzania' project. Additional policy interventions could bring these efforts to scale if accompanied by joint concerted action from all stakeholders including non-governmental organizations (NGOs), civil society organizations, the private sector, donors, international organizations, and researchers.

Internationally, Tanzania ratified the United Nations Framework Convention on Climate Change and the Kyoto Protocol in 1996 and 2002 respectively, and engaged in a legally binding emission reduction commitment and actions to address climate change. Following the ratification of the Paris Climate Agreement in November 2016, Tanzania has committed to cut GHG emissions by 10–20% by 2030, conditional on sufficient financial support. This commitment is anchored in the National Climate Change Strategy (2012), which elaborates adaptation and mitigation options. Agriculture and livestock are sectors for intended adaptation contributions including increasing crop yields and sustainable pasture management systems (United Republic of Tanzania, 2015).

In Tanzania, there is a pressing need for the development and scaling of climate-smart dairy production, one that leads to win-win environmental and productivity benefits and can be a future-proof model to other countries. Research conducted over the last decade provides key insights that can guide the scaling of climate-smart dairy development.

Farmers at a community plot testing different forages. Local livestock feed does not have the same nutritional value as improved varieties. Livestock farmers in the district of Lushoto, in the Tanga region of Tanzania, are finding ways of boosting their production and lowering their environmental impact by planting improved forages. ©Photo GeorginaSmith/2016CIAT


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RESEARCH INSIGHTS

Negative narratives overshadow the positive contributions that dairy can make to livelihoods and the environment

The livestock sector and its environmental impacts have been a subject of growing global concern. Livestock has been universally criticized for its large contribution to GHG emissions, air pollution, high water consumption, land-use change, and a loss of biodiversity (Paul et al., 2020a). In Tanzania, the agricultural sector is the second-largest contributor to national GHG emissionswith the majority due to enteric fermentation by livestock, followed by manure left on pastureUSAID, 2018). Overconsumption of animal source foods is also linked to adverse effects on human health. A diet overly rich in saturated fats and calories from meat, whole milk, and eggs is associated with increased risk of obesity, coronary heart disease, and some forms of cancer(Paul et al., 2020a)

Global media continues to be dominated by concerns about the adverse environmental and health impacts of livestock. These negative narratives overshadow the various complex and often positive roles livestock plays in low and middle-income countries like Tanzania. A singular focus on livestock-associated environmental impacts ignores livestock's crucial livelihood function in smallholder systems related to nutrition, income, asset provision, insurance, and nutrient cycling. Institutions such as the Food and Agriculture Organization of the United Nations have been building awareness of the contribution of the livestock sector to the sustainable development goals including economic growth, poverty reduction, ending malnutrition, gender equality, and ecosystem provisions. For example, the cereal-based diets of poor communities in Tanzania regularly lack bioavailable micronutrients, which are highly concentrated in livestock products (Paul et al., 2020a). A diet too low in iron, zinc, calcium, and vitamins A and B12 can lead to anaemia, vitamin A deficiency, and poor physical and cognitive development. Meat and dairy products can be good sources of these nutrients (Figure 1). Vulnerable groups in Tanzania, such as children and pregnant and lactating women, would benefit from more, not less, consumption of animal source foods to improve their physical and cognitive health and reduce impaired child growth . The negative narratives have contributed to a lack of public and private investments in research, policies and projects centred around livestock (Paul et al. 2020a).

A young girl plays with a cow at the home of Abel Mwandemange in the village of Ilemi outside of Mbeya, Tanzania ©Photo K. Dhanji/ILRI

Improved feeding and forages, together with better livestock genetics and health, can deliver win-win solutions for people and planet

Dairy development can provide substantial economic opportunities for smallholder farmers in Tanzania. Milk has been termed “white gold” for its potential to generate income. Upgrading and intensification of smallholder dairy development is a viable poverty alleviation strategy that can furnish income opportunities throughout the year, unlike crop income bound to harvest seasons (Paul et al., 2020c). Benefits propagated throughout dairy value chains are generated daily rather than seasonally . Furthermore, dairy production is a promising pathway for inclusive development, especially when women retain control over milk income (Notenbaert et al., 2020). Farmers can profit from higher milk production by selling it, but also by using it for home consumption, which can lead to health and nutritional benefits (Osele & Paul, 2019).

According to the projections of the Livestock Master Plan, Tanzania’s milk demand is expected to increase from the current average per capita consumption of 45 litres per year by 77% over the coming five years (Michael et al. 2018). The concomitant rise in livestock production could quickly become environmentally unsustainable. Climate-smart dairy intensification can help balance efforts to maximize milk yields, production, and profitability with long-term sustainability and environmental stewardship. In Tanzania, the primary aim is to improve smallholder livelihoods; mitigating negative environmental impacts is a co-benefit (Paul et al., 2020b).

MilkIT team visit field site during the MilkIT inception meeting in Amani, Tanzania. ©Photo Brigitte Maass/ILRI

Consistently scarce quantities and inadequate quality of livestock feed challenge Tanzania’s mixed-crop-livestock farmers especially during the dry season (Paul et al., 2020b). Feed also constitutes a significant dairy production cost. Tanzania has one of the lowest feed conversions for milk globally; thus, the highest amounts of feed are needed to produce milk, mainly due to poor livestock diets in smallholder mixed systems that rely on crop residues, grazing, collected vegetation, and other opportunistic feed. Since most cows are under-fed with low-quality grasses, milk production remains suboptimal (Figure 1) (Smith, 2016). One key approach to address feed scarcity and low productivity has been to develop improved feed and forage options (Paul et al., 2020d). Feeding improved forages benefits farmers with higher milk production for consumption and sale.

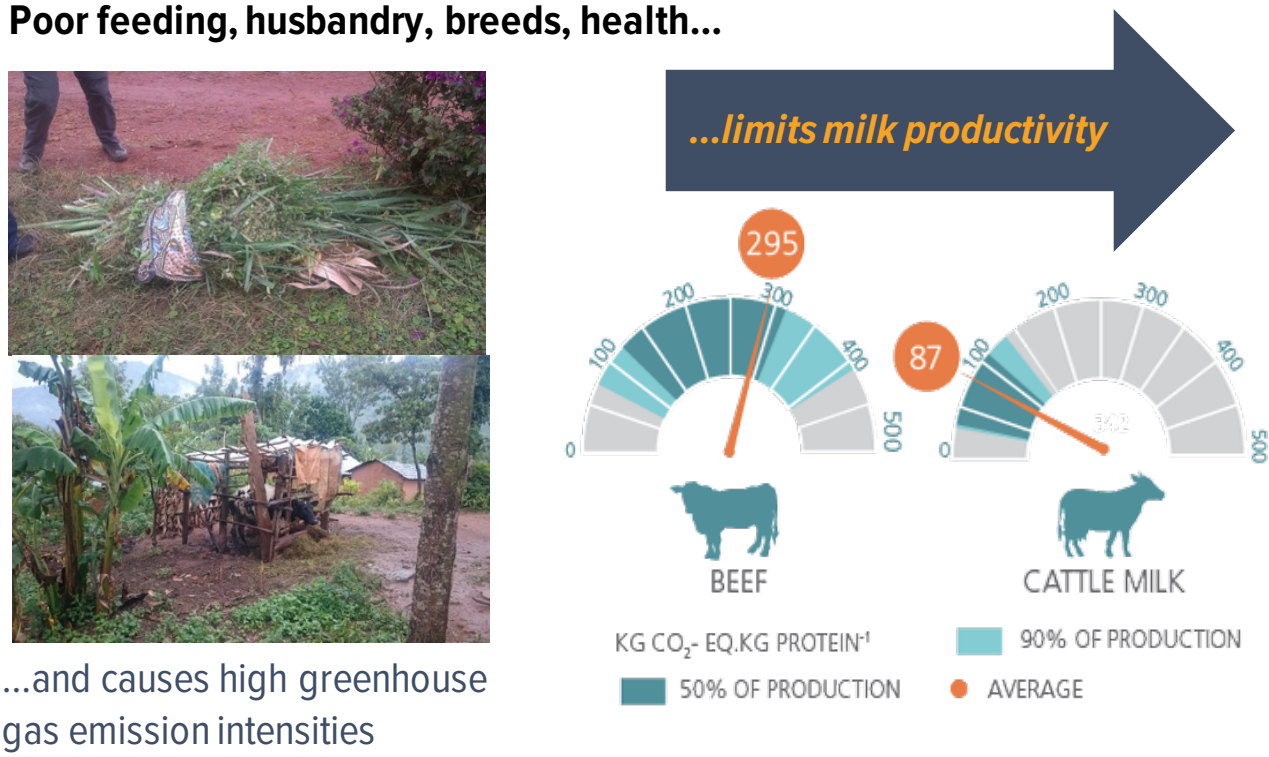

Figure 1: Poor livestock feeding limiting productivity and increasing greenhouse gas emission intensities

Improved livestock management is a key entry point for climate change mitigation. Livestock manure is a significant source of GHG emissions – particularly methane and nitrous oxide, which have 25 times and 300 times the global warming potential of carbon dioxide, respectively. On top of improving livestock productivity, tropical forages can deliver environmental co-benefits in terms of climate change mitigation and soil protection . Improved tropical forages include a wide variety of sown or planted grasses, herbaceous or dual-purpose legumes, and multipurpose trees and shrubs that are integrated into agro-pastoral, silvo-pastoral, and intensive or extensive mixed agriculture for grazing and cut-and-carry (Paul et al., 2020d). Higher-quality feeds mean livestock produces less GHG emissions because they are easier to digest and because proportionally less feed goes to maintaining the animal as compared to producing milk. In addition to shrinking GHG emissions per litre of milk, planted forages can boost soil organic carbon (SOC) through their deep-rootedness and perennial nature, promote soil rehabilitation, and improve soil quality (Paul et al., 2020d). Soils under well-managed forage grasses exhibit positive soil-health qualities such as proper organic matter concentrations, efficient nutrient use, low susceptibility to erosion, and good structure (Figure 2) (Korir et al., 2019).

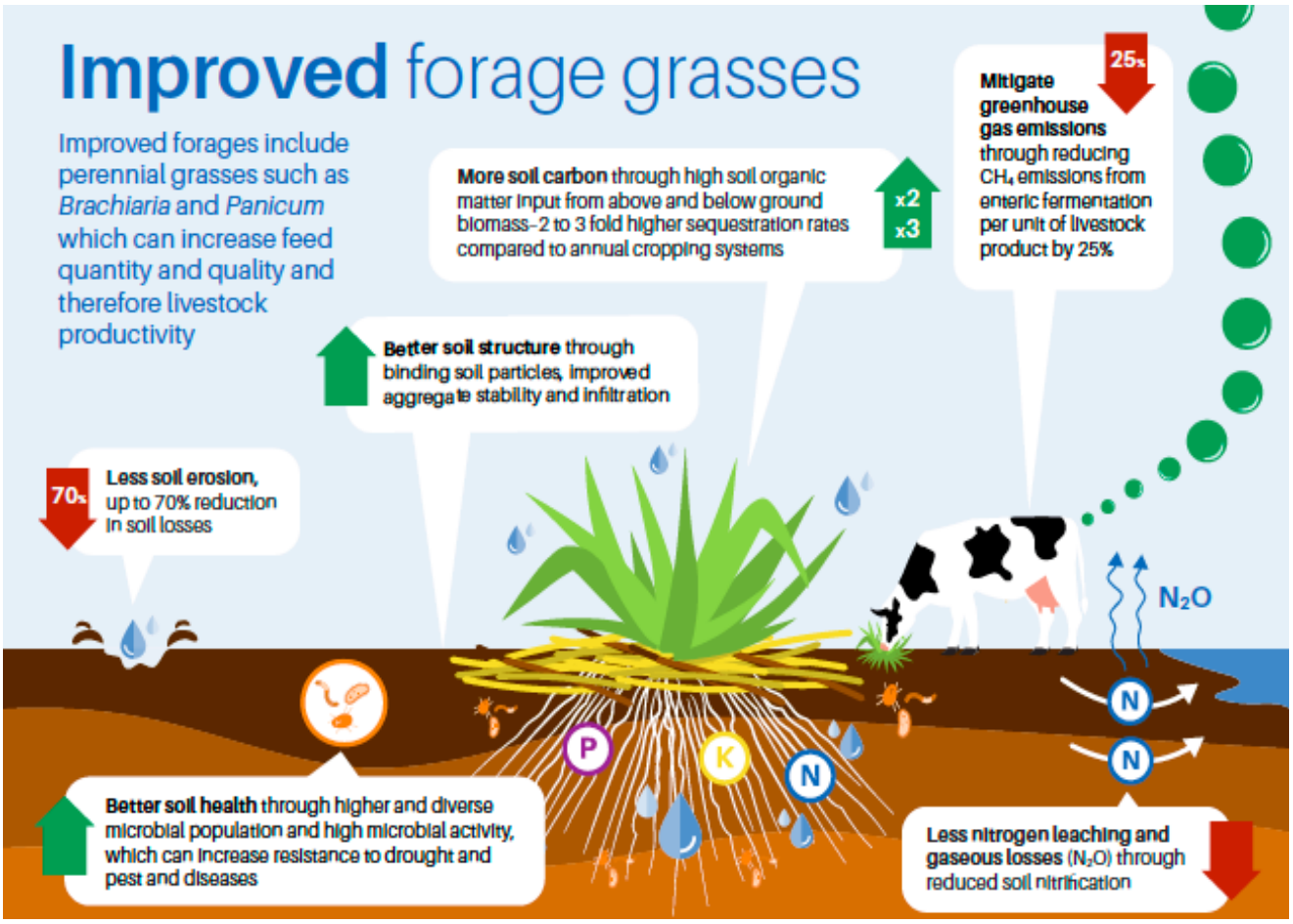

Figure 2: The environmental co-benefits improved forages deliver in terms of climate change mitigation and soil protection (Korir et al., 2019)

In the past two centuries, 70% of grasslands worldwide have been cleared or converted to agricultural land. This trend is expected to continue. Grasslands provide benefits such as livestock feed, environmental regulation, sequestration of soil carbon, biological diversity, and maintenance of soil health (Tessema et al., 2020). Forage grasses such as Napier grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*), and *Brachiaria* grasses are widely grown in dairy production systems in East Africa. Such grasses could help enhance SOC accumulation through increased aboveground and belowground biomass inputs. Conversion of cropland to grassland boosts SOC by about 19% (Nyawira et al., 2020). Enlarging SOC stocks through sequestration improves soil fertility and contributes to climate change mitigation by binding atmospheric carbon dioxide (Tessema et al., 2020).

However, climate change mitigation is not a primary objective of climate-smart dairy, but only a co-benefit of much-needed productivity increases. Farmers can profit through higher milk production and reduced time spent collecting grasses every day. Planting relatively small areas of improved forages can increase milk production by 10% and reduce GHG emissions intensity by 5% per litre of milk (Osele & Paul, 2019). The Comprehensive Livestock Environmental Assessment for Improved Nutrition, a Secured Environment and Sustainable

Development along Livestock and Fish Value Chains (CLEANED) is a rapid ex-ante environmental impact assessment tool that lets users explore multiple effects of intensifying livestock value chains in terms of improved income, food security, and environmental footprint. A CLEANED assessment carried out in Tanzania's Tanga Region estimated that dairy farmers and livestock stakeholders would be able sustainably to produce enough milk while reducing GHG emissions and other negative environmental impacts brought by poor daily management practices. Economically feasible farm-level productivity increased up to 140% and went hand-in-hand with up to a 50% reduction in GHG emission intensities (Notenbaert et al., et al., 2020). The CLEANED simulations in the Tanga Region also suggest that due to their current low productivity, the greatest efficiency gains in combination with relatively low increases in total GHG emissions would be made in extensive agro-pastoral dairy systems.

Reduced environmental footprints coupled with better animal genetics, feeds, and health interventions can be synergistic with productivity increases and higher incomes. Combined intervention packages work better than one-technology solutions (Notenbaert et al., 2020).

In summary, improved livestock feeding and forages can heighten productivity and incomes, decrease emission intensity as a co-benefit, increase manure quantity and quality, and improve soil fertility health. If well integrated with crop production, they can also heighten food productivity (Figure 3; Paul et al., 2020d). In Tanzania, there is urgent need for the development and adoption of climate-smart dairy production that leads to win-win environmental and productivity benefits.

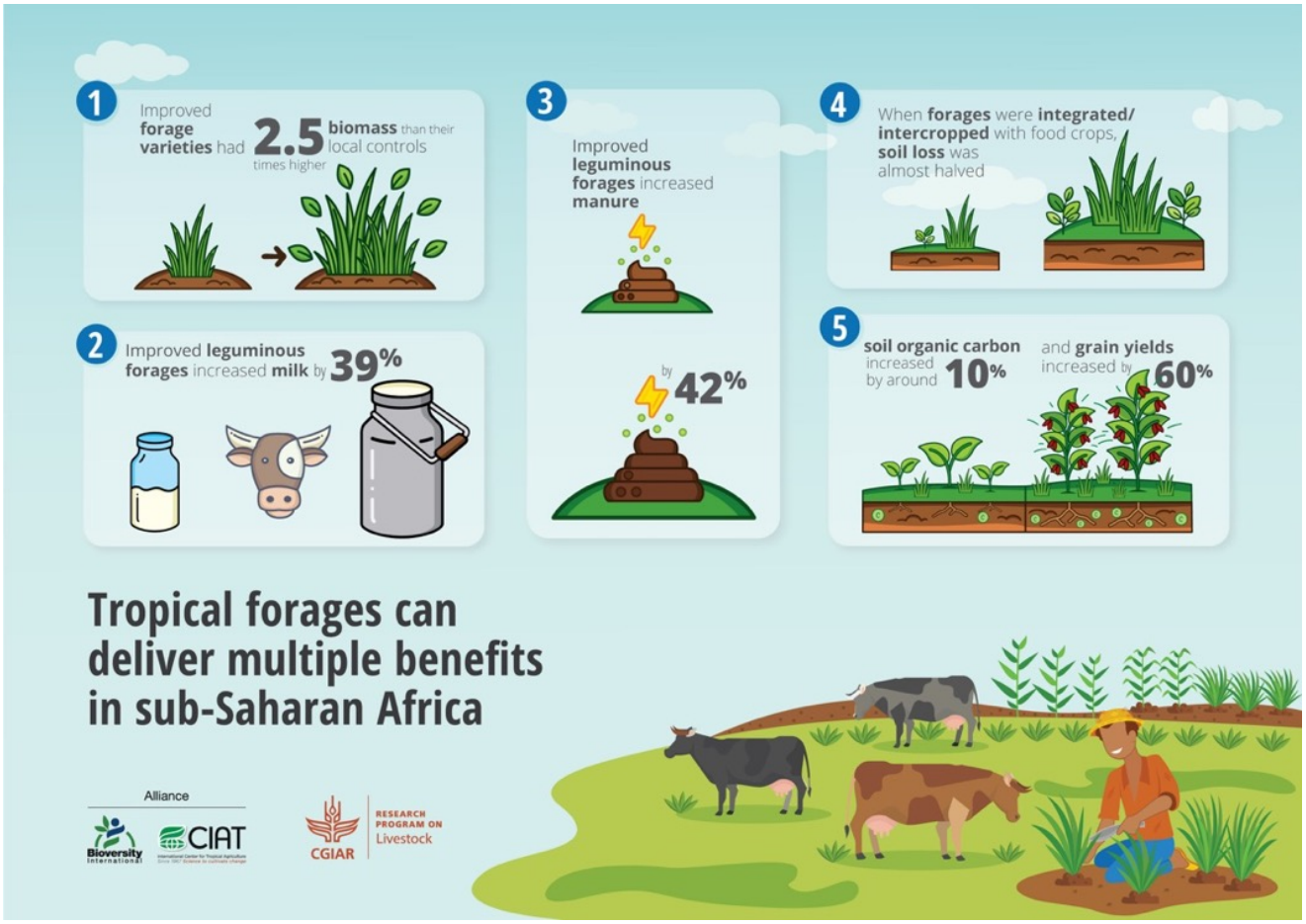

Figure 3: The multiple productivity and environmental co-benefits of improved forages in livestock productivity (Paul et al., 2020d)

Adoption of climate-smart dairy practices is limited due to a combination factors

Despite its large bio-economic potential, the adoption of climate-smart dairy practices is affected by social and institutional settings; these practices would include keeping animals with good genetic potential healthy and well-fed, storing and using their manure appropriately, and growing their feed sustainably (Paul et al., 2020c).

The main obstacles include the following:

1. **Lack of access to inputs and output markets, and knowledge and capacity building:** Sufficient planting material and extension advice on forage management and harvesting are not always available, and farmers lack training and capacity. The opportunity cost for labour is often low due to a lack of off-farm income possibilities, hence making it

favourable for farmers to collect fodder from distant places instead of saving labour by growing forages closer to the homestead. Low milk prices do not offer incentives to invest in improved feeding practices. (Ndah et al., 2017).

2. **Constrained land availability and access.** Land resource policies, and gendered access to land, pose problems for ensuring equitable access to land resources.
3. **Adoption of intervention packages are challenging.** Improved feeding needs to go hand-in-hand with a range of other technological changes including better animal breeds, appropriate animal shelters, the provision of drinking water, and the availability of veterinary services in order to reap satisfactory production responses. Such reorganisation requires capacities investment and experience that might not be present among resource-constrained smallholders.
4. **Dairy intensification can narrow the multi-functional potential of livestock and increase production risk**. In Tanzania, the provision of income and nutritious food constitutes only two functions of livestock. Livestock intensification may not be the main priority for farmers that primarily keep livestock for draught power, as assets, as a risk management strategy, or for cultural reasons such as identity status. These functions provide incentives for keeping large livestock herds at low productivity levels, instead of reducing stocking rates and investing in increased productivity.

To offset these issues, investments in knowledge transfer, more effective local authority and extension structures, stronger multi-stakeholder partnerships, access to loan and credit facilities, improvement of off-farm income possibilities, better access to input markets including for artificial insemination and forage planting material, access to financial services, and more favourable output markets can all boost future forage adoption rates. In general, producers who belong to associations showed higher adoption rates of improved forages. Finally, information, training, and education programmes can significantly heighten the adoption of technologies.

These research insights result in the following policy recommendations for the attention of diverse stakeholders to enhance scaling of climate-smart dairy development.

Livestock farmers in the district of Lushoto, in the Tanga region of Tanzania, are finding ways of boosting their production and lowering their environmental impact by planting improved forages ©Photo GeorginaSmith/2016CIAT

Co-chairman Buni Twahilu at a testing plot for different forages. Local livestock feed does not have the same nutritional value as improved varieties. Livestock farmers in the district of Lushoto, in the Tanga region of Tanzania, are finding ways of boosting their production and lowering their environmental impact by planting improved forages. ©Photo GeorginaSmith/2016CIAT

POLICY RECOMMENDATIONS

National and local government

- Foster cross-sectoral policy cooperation at local and national level between ministries working at the livestock-environment nexus
- Strengthen the role of dairy/livestock in land restoration and climate-smart agriculture planning, making them part of the solution
- Allocate resources to strategic priorities in climate-smart dairy development
- Guide and coordinate investments from other actors in climate-smart dairy development

Non-governmental organizations and civil society

- Make improved, climate-smart livestock management an integral part of rural development programmes targeting dairy farmers
- Increase training and capacity building in the use and management of improved feeds and forages to increase community adoption
- Enhance land use planning processes and explicitly consider intra-household decision making to allocate land for feed production

Research

- Attract accelerated investment in research for climate-smart dairy development
- Invest in the science-policy interface to translate research into practice and policy action
- Develop, target and tailor context-specific practices and technologies to heterogenous smallholder farming landscape across Tanzania

Funders and private sector

- Accelerate investment in programmes promoting climate-smart dairy production systems
- Advocate for climate-smart dairy production systems
- Showcase with investments how climate-smart dairy development can generate win-wins between profits and the environment
- de-risk private-sector investments in climate-smart dairy development using funds from public and non-governmental organizations.

Media and public awareness actors

- Create awareness of the win-win potential of the dairy sector in terms of productivity, environmental protection, and resilience with improved feeds.
- Disperse the knowledge that livestock keeping can be part of environmental solutions instead of the problem.

Mrs Mwakabila makes a sale of fresh milk at her home in the village of Mbalizi outside of Mbeya, Tanzania. Mrs Mwakabila has seen an improvement in the quantity and quality of the milk from her coes which she says is a result of better husbandry and feeding practices. ©Photo K. Dhanji/ILRI

AUTHORS

Dr. Birthe Paul is a scientist at the Alliance of Bioversity International and CIAT based in Nairobi, Kenya. Her work focusses on farming systems and the environment. b.paul@cgiar.org

Dr. Amos Omore is principal scientist, lead of Maziwa Zaidi II program and Eastern and Southern Africa Representative at the International Livestock Research Institute (ILRI) based in Dar es Salaam, Tanzania. A.omore@cgiar.org

An Notenbaert is a senior scientist at the Alliance of Bioversity International and CIAT based in Nairobi, Kenya. She has a background in land-use planning and coordinates the activities of the Tropical Forages Team in Africa. a.notenbaert@cgiar.org

Dr. Angello Mwilawa is Director for Research, Training and Extension at the Ministry of Livestock and Fisheries. He is based in Dodoma, Tanzania. angello.mwilawa@mifugo.go.tz

Prof. Erick Komba is Director General of the Tanzania Livestock Research Institute (TALIRI), based in Dodoma, Tanzania. ekomba@sua.ac.tz.

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RESOURCES

Carbon Brief Staff. (2017, February 6). *Paris 2015: Tracking country climate pledges*. COP21 PARIS. https://www.carbonbrief.org/paris-2015-tracking-country-climate-pledges

Curnow, M. (2020, November 2). *Managing manure to reduce greenhouse gas emissions* [Text]. Government of Western Australia Department of Primary Industries and Regional Development: Agriculture and Food. https://www.agric.wa.gov.au/climate-change/managing-manure-reduce-greenhouse-gas-emissions

Kauzeni, A. S., Shechambo, F. C., & Juma, I. (1998). Private and communal property ownership regimes in Tanzania. In *Land Reform: Land Settlement and Cooperatives*. http://www.fao.org/3/w8101t/w8101t06.htm

Korir, M. J., Paul, B., & Nyawira, S. S. (2019). *Assessing soil health benefits of forage grasses—A review of methods* (CIAT Research Brief, p. 16). https://hdl.handle.net/10568/107097

Michael, S., Mbwambo, N., Mruttu, H., Dotto, M. M., Ndomba, C., da Silva, M., Makusaro, F., Nandonde, S., Crispin, J., Shapiro, B., Desta, S., Nigussie, K., Negassa, A., & Gebru, G. (2018). *Tanzania Livestock Master Plan*. International Livestock Research Institute. https://cgspace.cgiar.org/bitstream/handle/10568/92405/livestockMasterPlan_Tanzania.pdf?sequence=1

Mordor Intelligence. (2019). *Dairy products in tanzania: Analysis of dairy and other related milk products with consumption and production trends (2020-2025)*. https://www.mordorintelligence.com/industry-reports/dairy-products-in-tanzania-industry

Mwema, E., Mukiri, J., Nzogela, B., Paul, B., Notenbaert, A. (in press). Assessing the environmental impacts of smallholder dairy intensification through improved feeding strategies in Southern Highlands of Tanzania. CIAT Working Paper. https://hdl.handle.net/10568/115055

Ndah, H. T., Schuler, J., Nkwain, V. N., Nzogela, B., Mangesho, W., Mollel, R., Loina, R., & Paul, B. K. (2017). *Factors Affecting the Adoption of Forage Technologies in Smallholder Dairy Production Systems in Lushoto, Tanzania* [CIAT Working Paper]. https://hdl.handle.net/10568/89500

©Photo K. Dhanji/ILRI

RESOURCES (Contd...)

Ngunga, D., Nzogela, B., Ngoteya, G., Kitalyi, A., & Paul, B. K. (2020). *Environmental Management Opportunities for Smallholder Dairy Production in Tanzania: Stakeholder Workshop Report*. Alliance of Bioversity International and CIAT. https://hdl.handle.net/10568/111298

Notenbaert, A., Groot, J., Herrero, M., Birnholz, C., Paul, B. K., Pfeifer, C., Fraval, S., Lannerstad, M., McFadzean, J. N., Dungait, J. A. J., Morris, J., Ran, Y., Barron, J., & Tittonell, P. (2020). Towards environmentally sound intensification pathways for dairy development in the Tanga region of Tanzania. *Regional Environmental Change*, *20*(138), 14. https://doi.org/10.1007/s10113-020-01723-5

Nyawira, S. S., Birthe, P., Korir, M. J., Nzogela, B., & Notenbaert, A. O. (2020). *Soil carbon accumulation under perennial forage grasses in the Southern Highlands of Tanzania*. International Centre for Tropical Agriculture (CIAT) and University of Nairobi.

Osele, V., & Paul, B. (2019). *Feed interventions to sustainably increase cows' productivity* (p. 1). International Center for Tropical Agriculture. https://hdl.handle.net/10568/107041

Paul, B. K., Butterbach-Bahl, K., Notenbaert, A., Nderi, A. N., & Ericksen, P. (2020). Sustainable livestock development in low- and middle-income countries: Shedding light on evidence-based solutions. *Environmental Research Letters, 16*(1), 011001. https://doi.org/10.1088/1748-9326/abc278

Paul, B. K., Groot, J. C. J., Birnholz, C. A., Nzogela, B., Notenbaert, A., Woyessa, K., Sommer, R., Nijbroek, R., & Tittonell, P. (2020). Reducing agro-environmental trade-offs through sustainable livestock intensification across smallholder systems in Northern Tanzania. *International Journal of Agricultural Sustainability*, *18*(1), 35–54. https://doi.org/10.1080/14735903.2019.1695348

Paul, B. K., Groot, J. C., Maass, B. L., Notenbaert, A. M., Herrero, M., & Tittonell, P. A. (n.d.). Improved feeding and forages at a crossroads: Farming systems approaches for sustainable livestock development in East Africa. *Outlook on Agriculture*, *49*(1), 8. https://doi.org/10.1177/0030727020906170

Paul, B. K., Koge, J., Maass, B. L., Notenbaert, A., Peters, M., Groot, J. C. J., & Tittonell, P. (2020). Tropical forage technologies can deliver multiple benefits in Sub-Saharan Africa. A meta-analysis. *Agronomy for Sustainable Development, 40*(22). https://doi.org/10.1007/s13593-020-00626-3

Puerta Rodríguez, C. D., Burkart, S., Enciso, K., Charry, A., Díaz, M. F., Gutierrez, J. F., Muñoz Quiceno, J. J., Ruiz, L. R., Vivas Quila, N. J., Albán López, N., Morales Velasco, S., & Peters, M. (2016, September 18). *Networking, information and technology adoption: A Social Network Analysis of Colombian small/medium scale cattle producers.* Tropentag 2016: "Solidarity in a competing world fair use of resources", Vienna, AT. International Center for Tropical Agriculture. https://hdl.handle.net/10568/77027

Smith, G. (2016, December 16). *An unlikely weapon against poverty and drought*. CIAT Blog. https://blog.ciat.cgiar.org/an-unlikely-weapon-against-poverty-and-drought/

Tessema, B., Sommer, R., Piikki, K., Söderström, M., Namirembe, S., Notenbaert, A., Tamene, L., Nyawira, S., & Paul, B. (2020). Potential for soil organic carbon sequestration in grasslands in East African countries: A review. *Grassland Science*, *66*(3), 135–144. https://doi.org/10.1111/grs.12267

The United Republic of Tanzania. (1999). *Tanzania Development Vision 2025*. https://www.mof.go.tz/mofdocs/overarch/Vision2025.pdf

The World Bank. (2021). *Overview*. Where We Work: Tanzania. https://www.worldbank.org/en/country/tanzania/overview

United Republic of Tanzania. (2015). *Intended Nationally Determined Contributions (INDCs)*. https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/United%20Republic%20of%20Tanzania%E2%80%8B/1/INDCs_The%20United%20Republic%20of%20Tanzania.pdf

USAID. (2018). *Tanzania GHG Emissions Factsheet*. https://www.climatelinks.org/sites/default/files/asset/document/Tanzania%20GHG%20Emissions%20Factsheet%20Final.pdf

World Bank Group. (2020). *Tanzania Economic Update: Addressing the Impact of COVID-19* (Text/HTML No. 14; Macroeconomics, Trade and Investment Global Practice, Africa Region). World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/850721591546081246/Tanzania-Economic-Update-Addressing-the-Impact-of-COVID-19

Cows eat fresh grass at the home of Abel Mwandemange in the village of Ilemi outside of Mbeya, Tanzania ©Photo K. Dhanji/ILRI

Investing in rural people

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CONTACT

An Notenbaert
Alliance of Bioversity International and CIAT,
Nairobi, Kenya
a.notenbaert@cgiar.org

Amos Omore
International Livestock Research Institute (ILRI)
Dar es Salaam, Tanzania
a.omore@cgiar.org

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