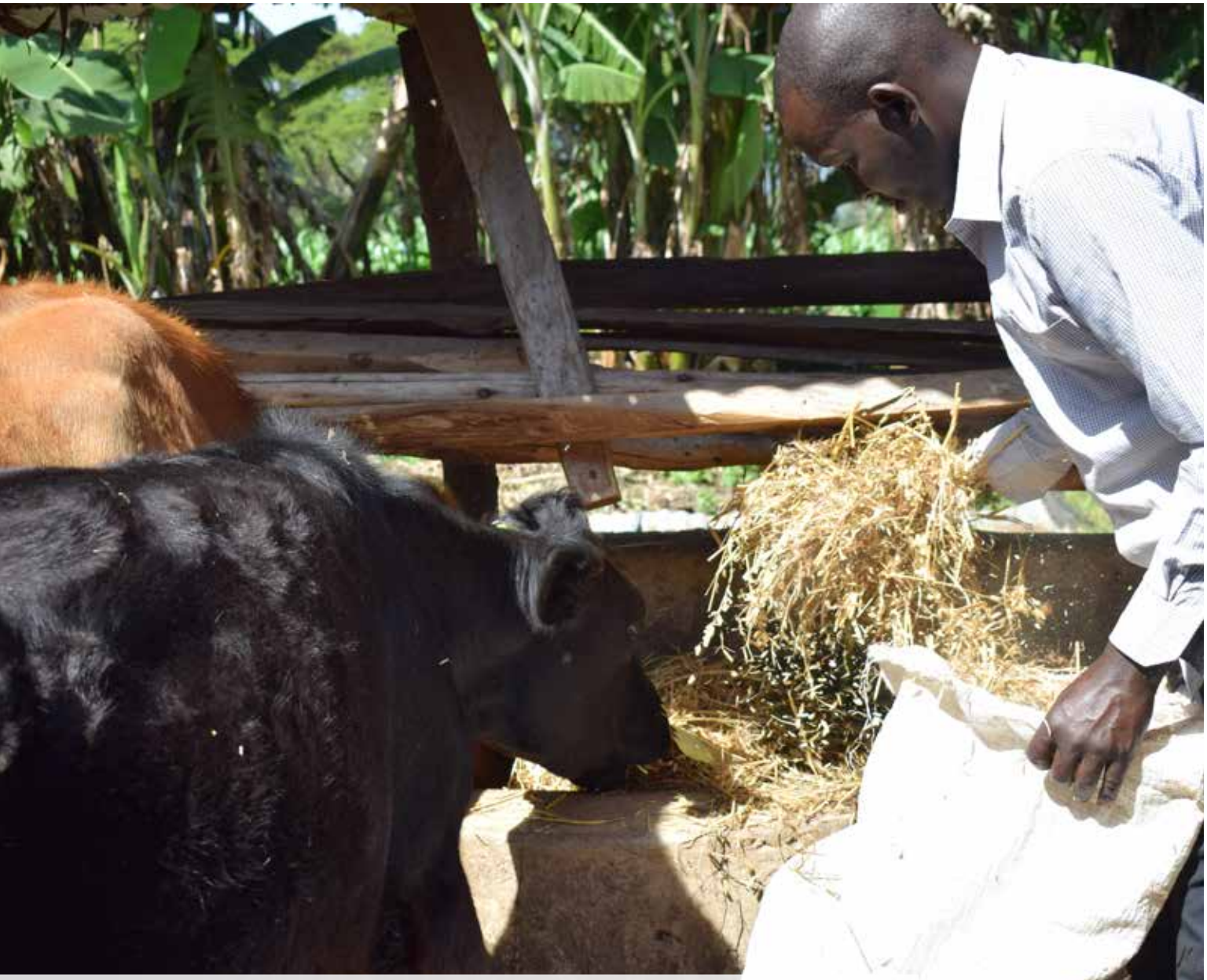

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Findings from the Programme for Climate-Smart Livestock Systems

Claudia Arndt, Leah Gichuki, Michael Graham, Shenkute Goshme, Birgit Habermann, Emmaculate Kiptoo, Daniel Korir, Sonja Leitner, Nathan Maiyo, Roland Mugumya, Daniel Mulat, Phyllis Ndung'u, Geoffrey Tugume, Ibrahim Wanyama, and Tigist Worku

Federal Ministry for Economic Cooperation and Development

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ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

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Key messages

- Ruminants such as cattle, sheep and goats produce by far the most greenhouse gas in livestock production.
- Some smallholder mixed farms in Africa emit relatively little greenhouse gas per unit of livestock protein produced, while others emit a lot. This shows there is potential to substantially reduce the intensity of emissions within smallholder systems.
- Inadequately fed cattle do not grow well and produce less milk – and they emit more methane per unit of feed than do well-fed cattle. Improving feeding improves animal productivity, reduces emissions per feed intake, and lowers emission intensity.
- Other ways to lower emission intensities include improving livestock health and access to water, switching to more resilient animal species and breeds for a given environment, and better manure management.
- But it is probably not realistic to reduce absolute emissions from livestock in Africa. Demand for animal protein is likely to increase because of the current low consumption and projected rises in population and incomes. The improvements above may help slow down the expected rises in emissions.
- "Adaptation pioneers" are livestock keepers who experiment with new technologies and innovations in their own farms as they seek ways to improve their productivity and its resilience.
- These pioneers can be a valuable, credible source of innovations and extension advice for their neighbours, as well as a source of ideas for further research. Linkages between pioneers, research and extension can be a powerful way to spread pioneers' innovations to other livestock keepers.

Ruminants such as cattle, sheep and goats produce greenhouse gas emissions in two main ways. Fermentation by microbes in their digestive tracts produces methane, which the animals emit when they belch. This is a powerful greenhouse gas: on a 100-year time scale, it is 28 times more powerful in terms of global warming than carbon dioxide. The other main source of greenhouse gas emissions is from the animals' manure, where the organic matter continues to break down under the influence of microorganisms. In addition to methane, this also emits nitrous oxide, an even more powerful greenhouse gas, 273 times that of carbon dioxide on a 100-year time scale.

Because both methane and nitrous oxide have such powerful effects on global warming, it is important to understand how much of each gas is produced and how much of it can be reduced or avoided through mitigation measures. For industrial processes, such as burning natural gas, this is easy: the amount of each type of gas produced varies little and can be calculated precisely.

The opposite is true for livestock-keeping, where emissions may vary widely depending on many factors – including the climate, the species and breed, the age and sex of the animal, the type and amount of feed it eats, its milk production, the distance it walks each day, and even how the manure is managed. Estimating greenhouse gas emissions from manure is especially complicated. What type of feed has the animal eaten? What is the daily temperature? How is the manure stored: in a dung-heap (which may or may not be turned over or exposed to sun and rain), left on the pasture where it is dropped, stored in liquid form, or used to produce biogas?

The Intergovernmental Panel on Climate Change (IPCC) provides default data and methods to support countries in estimating greenhouse gas emission factors: the amount of methane or nitrogen oxide that an animal, or its manure, is expected to emit over one year. The default values for Africa have only a few levels: for example, dairy cattle in Africa are classified into one of three categories based on their milk productivity: low (500 kg of milk a year), average (1,300 kg), or high (2,200 kg). But a wide variety of livestock systems exist in Africa. To make the estimates of emissions more accurate, it is necessary to classify the production systems in each country, collect data from farms that are representative of each system, and estimate the percentage of animals in each system. The farm data can then be used to calculate more precise emission estimates for that country.

The equations used by the IPCC to calculate emission factors are based on experimental data from developed countries, where animal types, animal production levels as well as environmental conditions and manure storage systems are very different from those in Africa. Hence, it is necessary to explore if the current IPCC assumptions and equations are representative and applicable to African systems. If not, they will need to be adjusted.

Photo: ILRI/Brigitte L. Maass

Fodder collected from the roadside can be a vital component of animals' diets

Such improvements will be useful in two ways. First, they enable governments to provide more accurate reports to the United Nations Framework Convention on Climate Change on the amount of greenhouse gases emitted. And second, they make it possible to seek ways to reduce greenhouse gas emissions by, for example, changing the animals' diets or improving how the manure is managed.

Opportunities for improvement

On the basis of farm data from highland East Africa, scientists at the International Livestock Research Institute (ILRI) have calculated that cattle emit less methane than the IPCC default values. (Sheep and goats, on the other hand, may emit more than the IPCC estimates.) At the same time, laboratory experiments showed that cattle emitted about 18% more methane per unit of feed intake than the IPCC figures. They also found that cattle that get less feed than they need produce more methane emissions per unit of intake.

In collaboration with national stakeholders, ILRI has collected data for selected livestock systems in Kenya, Tanzania, Uganda, and Burkina Faso. These data can be used to revise the levels of greenhouse gas emissions attributed to livestock in these countries.

A survey of smallholder farms in Nandi, Bomet and Nyando in western Kenya found a wide range of emission intensities on

Photo: Ibrahim Wanyama/ILRI

An unprotected pile of manure allows nutrients to seep into the soil and greenhouse gases to escape into the atmosphere.

different farms, depending on their level of production. Some of the farms had similar emission levels to farms in Europe, which are generally regarded as efficient. This shows two things: not all smallholder systems in Africa are unproductive and inefficient (as is sometimes thought to be the case), and there is ample potential for improving the less-efficient farms. In particular, ensuring that animals have sufficient, good-quality feed is important both to ensure their productivity and to keep their greenhouse gas emissions low.

Meeting demand while adapting to climate change

Climate change is already affecting livestock production in Africa. The weather and the seasons are becoming more unpredictable, and in many places it is warmer and drier than it used to be. Drought, heat and floods harm both livestock and crops. Africa's livestock keepers must somehow achieve three goals at the same time: increase their production and productivity, limit greenhouse gas emissions, and adapt to the changing climate.

Increasing production is necessary for two reasons: Africa's population is rising, and Africans still consume relatively little meat and milk – far less per person than recommended by the World Health Organization. That means it is not realistic to reduce the continent's overall emission levels from livestock, or indeed to cut the total number of livestock in Africa.

Reducing emission intensities

By far the largest amount of greenhouse gases from ruminant livestock production comes from microbial fermentation in the animals' digestive tracts. So that is where efforts to cut emissions should focus. Livestock keepers have little incentive to try to reduce their animals' greenhouse gas emissions per se. But fortunately, many of the changes that will help them to increase productivity and/or adapt to a changing climate will also cut the amount of emissions per kilogram of meat or milk produced.

Farmers who run mixed crop and livestock enterprises are tied to a particular location. With no spare land, they have to weigh trade-offs. Growing more forage for livestock takes land away from food production. Planting trees for shade and forage may reduce crop yields. At the same time, livestock produce meat, milk and manure, and turn crop by-products and pasture around the farm into food and income. Farmers may still be able to find ways to improve their livestock productivity within the constraints they face.

Some of these options require investment, which may be beyond the reach of subsistence smallholders. But other options (such as using crop residues as feed, and improving udder health) cost little or nothing. The most appropriate adaptations will depend on each livestock keeper's situation. The farmers' willingness to adopt them will depend largely on whether they increase animal productivity and farm incomes, and not on their impact on greenhouse gas emissions.

Feeding Improving the quantity and quality of feed enables animals to gain weight more quickly and produce more milk. This is particularly important in the dry season, when feed is scarce and animals are likely to lose weight. Livestock keepers can grow forage grasses, such as Napier grass or brachiaria, as a basal diet to ensure that animals have enough high-quality feed. The protein content of the diets can be increased with legumes such as lablab or desmodium, or trimmings from leguminous trees such as calliandra. Such crops enrich the soil by fixing nitrogen, and do not require fertilizer. Livestock keepers can also increase the output of fodder (and of food crops) by using irrigation, applying artificial fertilizer (though this is expensive) or manure, and cutting forage at the right time. They may be able to grow enough forage crops in the backyard, around field edges or intercropped with food crops, to feed a small number of animals. Some farmers may be able to use by-products such as rice husks or seedcake to improve the nutritional composition of the animals' diets. Poultry litter (suitably collected and handled) and weeds that grow around the farm can also be used.

It may also be possible to improve the storage and nutritional value of feed. Placing haystacks on raised platforms prevents the bottom layer from getting wet and rotting. Making silage can conserve more of the nutritional value of the feed and make

Photo: David Ngome/ILRI

Kenyan adaptation pioneer Felix S. checks his silage quality

Photo: Habtamu Apollo/ILRI

Kidane A., an adaptation pioneer in Ethiopia, shows his sheep to visiting farmers during his field day

use of good-quality crop residues. Chopping feed makes it more palatable and reduces wastage. Mixing wheat straw or maize stover with some green material, pre-treating it with a mixture of urea and water, or even just soaking it in water, makes it more palatable and nutritious.

Water Providing sufficient water is also important. Ensuring that the water is clean helps avoid diseases. For example, farmers can make raised water troughs to prevent animals from treading in the water and contaminating it.

Health Improving the health of livestock increases the proportion of nutrients that goes into production, so reducing the level of emissions per unit output. Providing adequate feed and water maintains the resilience of animals' immune systems. Veterinary care is needed to treat diseases that reduce production or may kill animals. Preventive health measures include veterinary care (such as deworming and vaccinating), improved housing, providing shade, proper hygiene during milking, and avoiding areas that are infested with tsetse and other biting flies. Keeping housing clean by collecting manure frequently and providing fresh bedding also limits the spread of disease.

Energy Avoiding the need for animals to walk long distances in search of feed and water (for example by keeping them in paddocks and cutting feed and carrying it to them) reduces their energy expenditure and ensures that more of their feed intake is converted into meat or milk.

Breeds and breeding Livestock keepers improve their current herds, for example by controlling the breeding, and by crossing with high-quality breeding stock or more resilient animals. If "improved" breeds are brought in, they must be kept under suitable environmental and feeding conditions to make use of their higher production potential. They often require more water, shade and better-quality feed than indigenous breeds. Livestock keepers can switch to more frugal or hardier species (e.g., from cattle to goats or camels), or to other breeds that are better adapted to the changed climatic conditions.

Animal numbers If livestock keepers can increase their productivity, they might be able to keep fewer animals while still producing the same amount of product. From an economic point of view this makes sense, as fewer cows will consume less feed, take less space, and perhaps require less labour and incur fewer expenses. From a greenhouse gas emissions point of view, one cow that produces 10 litres of milk a day is better than two cows that produce 5 litres each. On the other hand, farmers might prefer having two low-producing animals because they need lower-quality feed and require less care. Farmers often keep animals for multiple reasons, and cattle may fulfil more than one purpose on the farm. Better productivity might also tempt them to increase their herd size – raising emissions.

Manure management Many farmers currently either leave the manure on the pasture or in the livestock enclosure (*boma*, corral, or pen), or gather it into a manure heap. Others collect manure in a pit beneath or behind the animal housing. Some collect the manure, shape it into flat cakes and dry it to use as fuel.

A simple way to reduce greenhouse gas emissions from manure is to put the heap on an impermeable surface (such as a concrete

floor or sturdy plastic sheets), and to put a roof over it. The floor prevents nutrient losses from leaching and protects the groundwater from pollution. The roof protects it from the sun and rain, conserves nutrients, and increases its value as fertilizer. Turning the manure every couple of weeks ventilates it, increases the temperature of the heap, and kills off pathogens and weed seeds. It also reduces methane emissions from the manure. Adding other waste materials such as dry leaves, twigs and kitchen waste generates a rich compost that boosts soil fertility. Mixing the manure with the soil ensures that the nutrients are not lost and that plants can access them quickly.

Installing a biogas digester for manure produces methane that can be used for cooking rather than leaking into the atmosphere. The manure residue can be used as fertilizer instead of being dried and burned as fuel.

Other activities Livestock keepers may also respond to climate change by switching to other forms of farming. They, or their family members, may seek income from other sources, such as trading or wage employment. The effect of these changes on greenhouse gas emissions depends on the type of activity taken up.

Photo: ILRI/Lwitiko Mwakalukwa

Vaccinating livestock is important for their health and productivity - and reduces the intensity of their greenhouse gas emissions

Adaptation pioneers

Innovative livestock keepers in East Africa are finding solutions to the challenges of climate change on their own initiative. These "adaptation pioneers" are livestock keepers who conduct experiments on their farms, seeking ways to improve their production and the lives of their families. They may have have thought of the ideas to test themselves, or they may have picked up from somewhere else, and adapt them to their own needs. They often actively seek information on new technologies and then take a risk and test them on their farms. Sometimes they abandon those technologies again; sometimes they improve and adapt them through trial and error until they work. The ILRI scientists identified such pioneers in various locations in Ethiopia, Kenya and Uganda, and asked them to explain what they do.

Their innovations are wide-ranging (see map). They fall into several of the categories above. The most important related to feed and water.

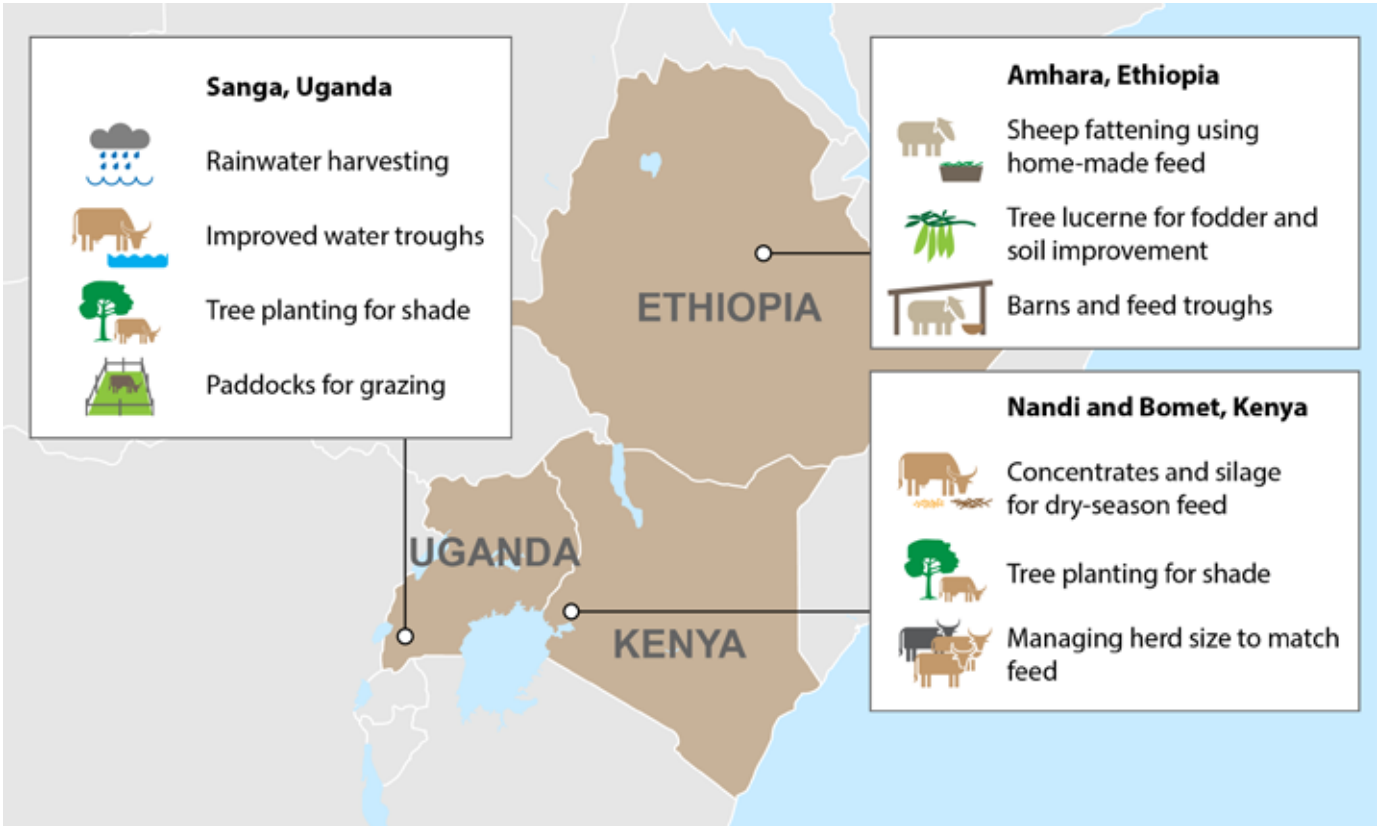
Feed Pioneers in Kenya found new ways of diversifying feeds for semi-intensive dairy to achieve a more balanced feed mixture for their cattle. They shifted from commercial to homemade concentrates to ensure quality and reduce costs. They started practising low-cost feed preservation methods, e.g., moving from pit silage to the surface silage method. This ensures they have enough feed for their livestock during the often-extended dry season.

Photo: Habtamu Apollo/ILRI

Adaption pioneer Tenagne G. fattens sheep for the Ethiopian Easter market

Photo: Birgit Habermann/ILRI

Edwin M. is experimenting with a mixture of sorghum with different crops for silage for his dairy cows in Kenya



Selected innovations by adaptation pioneers in mixed farming systems in East Africa

Pioneers in Ethiopia prepare homemade feed concentrate for sheep fattening from a mixture of crop leftovers and immature crops. They chop and grind this to a powder to replace market-bought feed during the dry season. They either mix this powder with crop residue or make *kita*, a kind of roasted flat bread, to use as feed. Furthermore, they replace feed from expensive brewery by-products with a homemade mix made from brewing local drink. Making feed themselves cuts the costs and ensures quality.

The pioneers also grow fodder crops such as vetch, oats, tree lucerne and alfalfa in their backyards. They construct separate barns and feed troughs from iron sheets and wood for fattening sheep. This cuts feed wastage, permits proper feeding, and reduces the need for labour.

Ugandan pioneers combat invasive species such as *Sporobolus* grass, which cattle do not like to eat, by uprooting it and then leaving the land fallow, allowing the native grasses to recover.

Water Pioneers in Uganda have constructed underground tanks to harvest rainwater from rooftops, and have built dams and excavated ponds to collect surface runoff. They keep animals out with hedges or barbed-wire fences, and transfer the water by hand or with a pump into a drinking trough for livestock. They desilt the ponds to maintain the storage capacity. Some pioneers lay pipes to carry water to troughs in the animals' night enclosures.

Health Pioneers plant (or maintain) trees to provide shade for their animals. They herd the animals in areas with fewer ticks or tsetse flies. Cutting and carrying fodder reduces the transmission of diseases by preventing animals from coming into contact with other livestock or wild animals.

Energy Providing more watering points and keeping animals in paddocks rather than allowing them to graze on open land reduces the energy they expend in moving around.

Breeds and breeding Pioneers want breeds that are both resilient and productive. They use artificial insemination and selective breeding to improve their stock. They separate male from female animals, and bring in breeding stock from outside to prevent in-breeding.

Animal numbers They manage their herd size according to the resources they have available. They know the importance of feed quantity and quality for productivity and health, so avoid keeping more animals than they can maintain.

All of these innovations show how pioneers adapt to a changing climate. Many pioneers reduce the quantity of emissions per kilogram of animal protein produced through how they manage livestock. Some measures (such as eliminating unproductive stock) will also reduce the total amount of greenhouse gases emitted, so contribute to climate change mitigation as well as adaptation.

Spreading messages and influencing research

The adaptation pioneers are often well-known in their communities as having innovative ideas and for being bold enough to conduct experiments on their farms. But they do not always know how valid their experiences are for other farmers. Knowledge sharing between farmers can be limited, so the pioneers' innovations often fail to spread to their neighbours.

ILRI helps the pioneers to promote their ideas via farmer-to-farmer exchanges such as field days, demonstrations and networking. This has several advantages over the more usual approach of extension workers informing livestock keepers about technologies developed by research. The pioneers' innovations have already been field-tested and refined, so are more likely to suit local conditions than those developed on an experiment station. Livestock keepers are more likely to listen to local pioneers than to an outside extensionist. Extension services are anyway often poorly resourced and thinly spread. Adaptation pioneers can, with a little assistance, form local networks with interested neighbours to further develop and disseminate technologies.

The pioneers are also an important source of ideas for research. Their innovations can inform scientists about the types of research that are likely to be most useful for livestock keepers.

Photo: Pamela Wairagala/ILRI

Phoebe K. and her farm worker check the quality of the Napier grass that she feeds to her dairy cows

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Photo credits: Front: Kenyan adaptation pioneer Felix S. feeds his cattle (Photo: David Ngome/ILRI). Back: Kidane A. and his wife Wilta M. feed their sheep with tree lucerne (Photo: Habtamu Apollo/ILRI).

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