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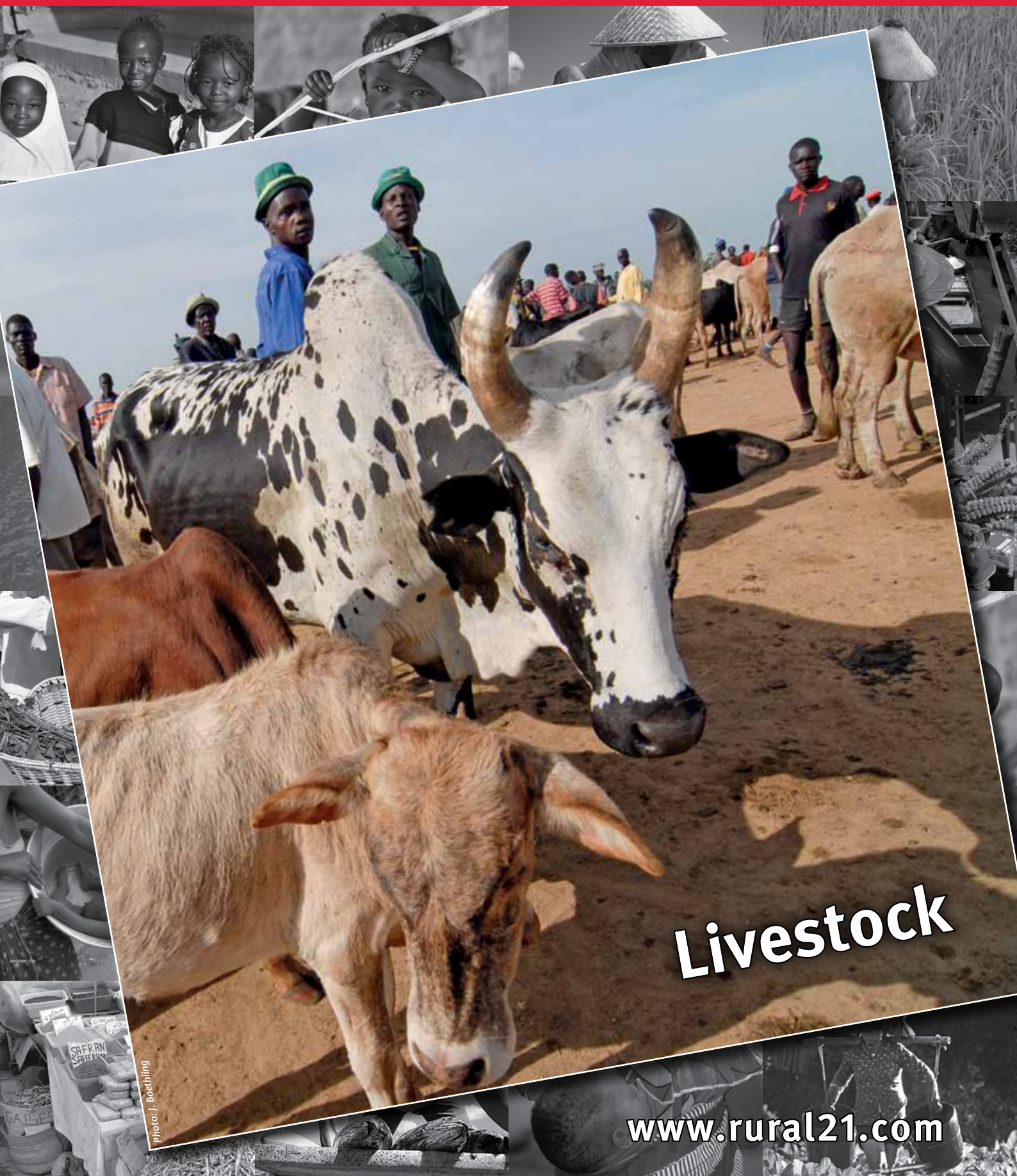

Editorial

Dear Reader,

The livestock sector creates livelihoods for an estimated one billion people world-wide. Not only is the consumption of milk, meat and eggs an important source of protein and micronutrients and hence a crucial pillar of food security for the rural poor in particular. For many people, the sale of animal products is the most important, if not the only, source of income. In addition, the animals are a significant multifunctional asset. They provide dung, raising soil fertility, they are simultaneously beasts of burden and tractors, and they represent "hoofed insurance", not to mention the social prestige that they endow their owners with.

In spite of its important role, animal production has been an unfavourable topic in the development debate – also owing to the UN Report "Livestock's Long Shadow", which drew attention to the environmental impact of animal husbandry in late 2006. After all, animals account for two thirds of all climate gas emissions from agriculture; water pollution and loss of biodiversity are attributed to animal husbandry as are the transmission of animal-borne diseases to humans and unhealthy food, not to mention competition with other areas of food production – crops for livestock feed are grown on a third of cropland world-wide.

There can be no doubt that "no animal husbandry" is not an option. Without it, food security and poverty reduction in the countries of the South would be impossible. Moreover, it is a fact that the global demand for animal products is above all going to rise in the developing countries and the emerging economies. If the current trends continue, an annual 470 million tonnes of meat will have to be produced annually by 2050 – that is 170 million tonnes more than today. Is it at all possible to meet this growing demand in a sustainable manner? And if so, how can it be ensured that small livestock keepers also benefit, instead of being left out – as is so often the case in the transition from traditional to industrial-type modes of production?

With this edition of Rural 21, we want to take a look at the current state of debate. Our examples show how extremely diversified animal husbandry is and which different challenges the livestock keepers face because of this. In the former Soviet Central Asian republics, for example, the livestock sector experienced a de-intensification after the collapse of the Soviet Union. Animal husbandry is now more and more reliant on the natural pastures. However, insufficiently settled landed property rights complicate their sustainable use; governments are only half-heartedly supporting reforms (p. 16). In the Horn of Africa, prolonged armed conflicts are aggravating the already existing problems of the pastoralists – competition for access to water points and grazing land, and disputes over livestock trespass and tribal conflicts. With its animal health projects in Sudan and South Sudan, the organisation Vétérinaires Sans Frontières Germany is not only creating a better food situation for the population concerned, but in doing so it is also supporting the peace building process (p. 19). But animal husbandry is not only important for marginalised people in remote rural areas. For several hundreds of years, chickens and rabbits, sheep and goats, but also pigs and cattle have secured the livelihoods of townspeople as well. However, the major share of this production takes place in the informal sector, and usually in confined conditions with insufficient hygiene, so that diseases among humans and animals alike are inevitable. Appreciating the beneficial role of urban livestock husbandry by governments and considering it in municipal planning could greatly help to improve the situation (p. 28).

Our examples on pages 22-27 show how poor livestock keepers can successfully be linked to markets. In addition to their integration in contract farming systems, the hub approach in particular – a mechanism to upgrade the value chain by facilitating market linkages – has proved to be promising. It centres on producers' organisations, which are provided with the necessary inputs and services – ranging from training and advice on improved feed and animal genetics to transportation and storage facilities for their produce. Within just a few years, many dairy farmers in sub-Saharan Africa and South Asia have achieved considerable increases in their milk production.

Of course, regardless of the opportunities that animal husbandry offers in food security and poverty reduction, its negative impacts must not be ignored. Our authors from Latin America show how rangeland management can be made climate-smart with a clever choice of feed (p. 12); in the Scientific World section, we present state-of-the-art research results on the various ways to reduce the greenhouse gas footprint of livestock production. And finally, the authors in our Opinion section once again take a look at the global dimension of animal husbandry, calling for a change of mindsets – both in livestock farming and among consumers.

We wish you inspiring reading!

Silvia Richter

Partner institutions of Rural 21:

BMZ Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung

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Global Hunger Index 2014: The challenge of hidden hunger

Throughout the world, 805 million people are going hungry, while far more, in fact over two billion, are suffering from so-called hidden hunger, a form of malnutrition based on a lack of micronutrients. Also, flight, displacement and civil war are having drastic impacts on the food situation. These are some of the key findings of the World Hunger Index 2014 that Welthungerhilfe presented together with the International Food Policy Research Institute (IFPRI) and the relief organisation Concern Worldwide in various countries in mid-October 2014. At the presentation in Berlin, Germany, Welthungerhilfe President Bärbel Dieckmann highlighted the considerable influence that conflicts have on the population's food situation. For example, in this year's World Hunger Index, Iraq has scored the second worst result of all countries; there, the share of hungry people has more than doubled since 1990. Developments in Syria and South Sudan are worrying, too. Refugees are always exposed to an increased danger of food insecurity and disease, as well as a worsening provision of primary health care in the countries affected.

Dieckmann warns that the situation in West Africa can also quickly become alarming, and maintains that the Ebola epidemic in the countries concerned is going to have a considerable impact on the food situation. "People have to join forces throughout the world to address these challenges. We must have the courage to display unconditional solidarity," Dieckmann said.

The indicators

The 2014 Global Hunger Index (GHI) is calculated for 120 countries for which data are available for three indicators: the proportion of people who are undernourished, the proportion of children under five who are underweight, and the mortality rate of children under age five. In future, the second indicator, which establishes the number of underweight children, is to be extended by the factors "stunting" (children who are too small for their age) and "wasting" (children who are too light for their age), says IFPRI staff member Klaus von Grebmer.

Out of the 120 countries, 44 record a situation of "little hunger", so that only 76 countries have been included in the ranking. The necessary data are not available for a large number of other countries, including Afghanistan, the Democratic Republic of the Congo, Myanmar, Papua New Guinea, and Somalia. (For detailed information on the GHI, see ➤ **www.welthungerhilfe.de**)

The problem with hidden hunger

While the data base for the above-mentioned indicators is already more than poor, as von Grebmer criticised introducing the report, this applies all the more to hidden hunger. For as its name implies, the problem is that it takes effect before one sees it. Moreover, it is difficult to measure, nutritional scientist Hans Konrad Biesalski explained during the subsequent panel debate. Regarding vitamin A deficiency, for example, children are highly vulnerable to infections. Among girls, there is an increased risk of suffering premature births later on in life or dying when giving birth. However, as a rule, the deficiency is only spotted when the first symptoms appear. This also applies to zinc deficiency. It leads to cells dying in the intestines that release zinc, so that the blood count initially suggests a high or sufficient supply of zinc. Biesalski also stresses that more and more children are suffering from both malnutrition and supernutrition.

Acute interventions are only one side of the coin

In the debate over possible ways of tackling micronutrient deficiency, the participants in the panel debate agreed that food supplements and fortification could only be temporary strategies, whereas the goal had to be a diversification of food – which however was difficult to achieve. "Increases in productivity and higher income alone are not sufficient to solve the problem," said Birgit Poniatowski of the Global Alliance for Improved Nutrition (GAIN). Biesalski emphasised that it was important to always check first which food was locally available, and also eaten, i.e. accepted, by the population. Otherwise there was a danger e.g. of the food supplied quickly landing in the pig's trough. He added that although acute interventions to tackle the effects of deficiencies were important, they could only be successful in the long run if a sustainable development of small-scale agriculture was taking place at the same time.

Welthungerhilfe Secretary General Wolfgang Jamann presented corresponding integrated approaches such

A young mother in a vegetable garden in Zambia.

Photo: G. Bentley/Welthungerhilfe

as the project "Realigning Agriculture to Improve Nutrition" (RAIN), which the organisation is conducting in Zambia together with Concern Worldwide. In addition to small livestock husbandry, it focuses on kitchen gardening in which a wide range of useful plants are grown that bear a high nutritional value. For example, beans enriched with iron are grown that are very popular among the population thanks to their short cooking time and tastiness. Moreover, community health assistants working in an honorary capacity and specially selected smallholders run training programmes on agriculture and food for pregnant women and mothers of infants on a continuous basis. In addition, the pregnant women are given iron and folic acid preparations and the children vitamin A supplements twice a year. Just below 4,500 households are reached by the programme.

Silvia Richter

Family farming is the only solution for food security!

One of the key demands raised at this year's World Food Day Colloquium by Jock R. Anderson, former Agricultural Policy and Strategy Advisor to the World Bank, was that humanity should not tolerate food insecurity. The Colloquium, traditionally held by the Food Security Center of the University of Hohenheim, Germany, on the 16th October, World Food Day, dealt with the topic of "Family farming – a solution for food and nutrition security?"

Anderson maintained that making sustainable progress in combatting hunger and malnutrition was a great challenge. One crucial instrument in this context was agricultural research, a field in which above all the countries affected by hunger were unfortunately investing far too little. Here, Anderson held that the public sector and, in particular, the private sector, had a role to play, with the public sector having to set the environment for private investments.

Cows can help escape poverty

The family farms still bear a considerable potential to make a sustainable contribution to food security. Various examples of how this potential can be made use of were shown at the Colloquium. Narayan Hegde of the BAIF Development Research Foundation in Pune, India, gave an account of the organisation's experiences. BAIF activities above all focus on the rural poor and smallholders. They lack irrigation options, their fields provide little yield, and livestock yields are poor, too. On average, the rural poor in India spend around 60 per cent of their income on food. "Enhancing the productivity of family farms is the challenge India has to deal with," Narayan Hegde told the meeting. Alongside water resource management, improvement of paddy production and the introduction of agri-horti-forestry, adopting animal husbandry in the smallholder farms and improvements in livestock production have proven most successful, especially with regard to dairy. Now there are 4,000 milk collection centres in 16 Federal states to which around four million families in 100,000 villages belong. With cows from native breeds, they produce milk with a value of 1.4 billion US dollars each year. After five years, the centres are self-sustaining.

Training the youth is essential

Sr. Maria Vida C. Cordero of the Archdiocese Manila and Agricultural Advisor to the Philippine Ecology Ministry introduced the audience to the sustainable agriculture approach of MASIPAG. MASIPAG is a farmer-led network of people's organisations, NGOs and scientists working towards the sustainable use and management of biodiversity through farmers' control of genetic and biological resources, agricultural production and associated knowledge. The network's core values include a bottom-up approach, farmer-scientist partnership, farmer-led research and training and a farmer-to-farmer mode of transfer, just to mention a few. Sustainable agriculture for smallholder farmers needs diversification and integration to bring income and social security to the family. At the Hohenheim conference, Cordero stressed the very important role of training the youth in sustainable agriculture in the sustainable development of the family farms.

Another concept to increase food security is nutrition-sensitive agriculture. Hannah Jaenicke, Coordinator of the Horticulture Centre of Competence, Bonn, Germany, presented six case studies the aim of which was to analyse the entry points for nutrition-sensitive agriculture. Enabling policies are of particular importance, as the example of Brazil showed. There, the government orients its policies on supporting family farming, as well as on food and nutritional aspects and development. Further suitable entry points include elements of the food chain and also the topic of livestock. Appropriate beneficial groups, awareness and capacity building and mechanisms of collaboration are additional aspects that a nutrition-sensitive agriculture can take up. In many cases, the role of collaboration is over- or underestimated.

If the smallholder family farmers are to make a sustainable contribution to more food security, they need to have a greater say and have to become more integrated in decision-making processes. One result of the discussion was that this also applied in particular to the better involvement of women. Furthermore, there were calls for more farmer-oriented research and action and farmer-driven innovations. More investment in government-supported agricultural extension and better training of consultants was another option to achieve this goal. But, the discussion revealed, family farming is the only solution to food security, even if it is not an easy one.

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Livestock matter

Livestock are critical to building sustainability in food and agriculture. Current and future livestock sector development needs to produce more, from less, and in ways that benefit all. Solving the sector's challenges requires stakeholders to find common ground and to join forces towards continuous practice change. The Global Agenda for Sustainable Livestock is one example of these new ways of working.

Photo: N. Palmer for FAO/PPLPI

Livestock and livestock products are criticised for contributing to unhealthy diets, climate change and competition over grains. Mixed with concerns about animal welfare and a recent string of food safety scandals, it sometimes appears that the world would be better off without livestock.

The opposite is true. We need livestock, animals that we use for food and other products and as a component of mixed farming world-wide. By turning our attention away from livestock, we risk missing out on large development opportunities.

The vast diversity in livestock systems world-wide and the different demands and expectations placed on the sector have contributed to the difficulties for public policy in comprehensively addressing the sector. This diversity has also added to a poor understanding of how the sector, given an increasing world population, growing scarcity of natural resources and accelerating climate change, can best contribute to the world's need for sustainable food and agriculture.

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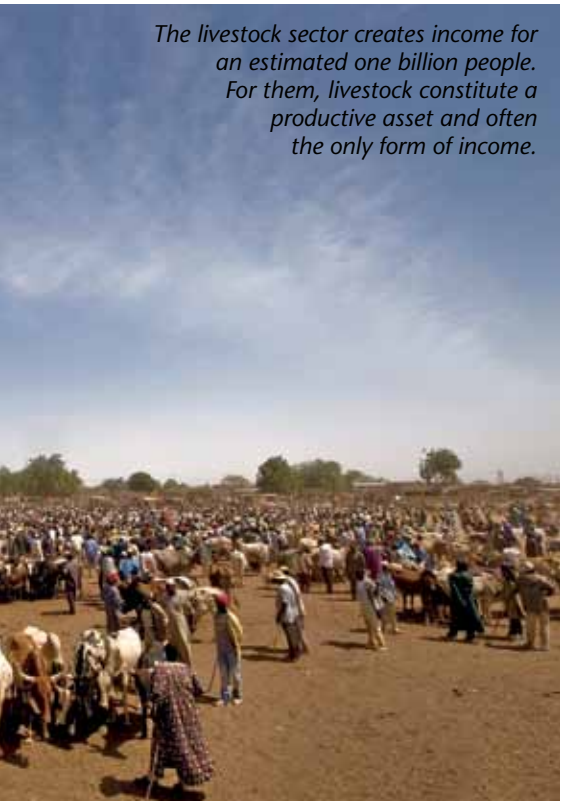
Food security and livelihoods

Traditionally, livestock has served to turn resources that humans can't use directly, such as grazing and crop residues, but also agro-industrial by-products and diverse forms of waste, into valuable products and services. Even today, this continues to be the case: more than 80 per cent of all livestock feed is not edible by humans. In many countries, livestock are making large net contributions to food supply. In India alone, the net protein supplied by the dairy sector (edible protein provided by livestock minus edible protein fed to them) meets the protein requirements of 150 million people.

Consumption of meat, milk, and eggs is growing rapidly in many developing countries, driven by growing populations, rising incomes and urbanisation. These richer diets are welcome because livestock products provide micronutrients such as vitamin A and B12, riboflavin, calcium, iron and zinc, which are critical to growth and development in humans. However, in many developed countries, and increasingly also in developing countries, people are consuming in excess of their needs.

The livestock sector creates livelihoods for an estimated one billion people. For them, livestock constitute a productive asset and often the only form of income. Livestock provide not only food, but other products like leather or wool, traction and manure as well. They increase and stabilise rural incomes. No other sector contributes so strongly to the lives and livelihoods of the most marginalised people. Many of them are poor and live in marginal areas, with low education and poor health. Here, improving livestock production, for example through vaccinations and better feed, can make critical contributions to nutrition and incomes. More commercialised livestock operations provide employment, and are a growth component of many rural economies, often with few other options.

Livestock account for about 40 per cent of global agricultural gross domestic product. Whilst the continuous growth of the sector undoubtedly offers many opportunities, its intensification and specialisation may also lead to the marginalisation of those that cannot take part in this growth. This contributes to a further erosion of the rights of indigenous people and contributes to the use of child labour in certain livestock production systems. Value chain development, however, can also remove barriers for some smallholder producers to enable access to more lucrative markets and contribute to more equitable growth. An im-



The livestock sector creates income for an estimated one billion people. For them, livestock constitute a productive asset and often the only form of income.

portant part of the livestock sector's contribution to growth requires incentives and institutions that increase market participation by smallholders.

Natural resources and climate change

Livestock's environmental impact looms large. The livestock sector is the world's largest user of agricultural land, through grazing and the use of feed crops, and plays a significant role in climate change, management of land and water, and biodiversity. Growing demand is mostly met through intensification, leading to industrial-type modes of production that are productive in the use of feed and animals, but often have negative social, environmental and animal welfare implications.

Twenty-six per cent of all land is used for grazing, and 33 per cent of cropland is used for cultivation for livestock feed. Livestock production is also often implicated as a significant source of water pollution, particularly from confined types of production. The sector contributes an estimated two thirds of all agriculture's climate emissions, but large potential exists to reduce the emission intensity of the sector through resource use efficiency gains, in addition to significant carbon sequestration potential as part of the many ecosystem services the sector may provide. Wider adoption of existing good practices and technologies in feeding, health and husbandry, and manure management – as well as greater use of currently underutilised technologies such as biogas generators and energy-saving devices – could help the global livestock sector significantly cut its outputs of global warming gases.

Livestock manure is often an important input to maintaining soil fertility, and so contributes to greater crop production for food and income, lowering the need or purchase of synthetic fertilisers. In some areas, dung is also used as a fuel. Dung for fertiliser, fuel, and building material is often a marketable commodity. In these systems, cattle, and other animals, also often provide traction for transportation and crop production, for domestic use and for hire.

Crop and pasture expansion into natural ecosystems has contributed to livestock production growth and will continue in the future. Most expansion arises through the clearing of forests, resulting in losses of environmental goods and services, including stored carbon, biodiversity, water, and air quality – however, such expansion has been much reduced recently through more effective policies, for example in Brazil.

Payment for environmental services (PES) is a potential tool for increasing the value of livestock production systems. Currently, however, in many developing country contexts, where there are market imperfections, land tenure issues and broader development needs of land users, conditional payments for environmental services may be less relevant than more general investments in production systems and livelihoods.

Livestock is often instrumental in landscape management and in enhancing biodiversity in numerous settings, although it has also been indicated to pose a threat to biodiversity in 40 per cent of all ecoregions. Biodiversity of animals – and domestic animals in general – appears to be under threat in countries where breeding policies and subsidies may restrict the choice of breeds. And whilst genetic similarity has been an important factor in advances made in resource use efficiency, the maintenance of genetic diversity will be key to livestock's role as a tool of adaptation in a context of ever-evolving production, disease, and climate threats.

Health and disease

Producing with animals and the perishability of most livestock products also puts special demands on their marketing and preparation to prevent contamination and other food safety risks. For the poor people in developing countries, food-borne disease is frequent and generally underreported.

The widespread use of antimicrobial drugs for preventive measures or as growth promoters is of mounting concern. Inappropriate use may contribute to increasing microbe resistance, which makes these drugs ineffective in treating infectious diseases or parasitic infections in humans and animals. The use of such drugs has grown as livestock systems are intensifying around the world. Residues harmful to consumers can also be an issue in certain types of production systems.

Intensive large-scale production often involves the geographical clustering of genetically similar animals. Strong biosecurity and health protection regimes generally prevent infectious disease problems, but major outbreaks occur when a pathogen evolves to a higher virulent form, eludes the vaccine used, acquires resistance to antibiotics, or enters undetected into the food chain. Smallholder livestock systems – which tend to involve animals roaming freely over large areas, but still in relatively high densities – also facilitate disease spread, both among local animal populations and

over large distances. Livestock connect wildlife and environmental health to human health, and are an important element in disease emergence and transmission. Seventy per cent of all new human diseases originate from animals, mostly from wildlife.

Well-known diseases also continue to cause large losses to production and livelihoods. Outbreaks of notifiable diseases disrupt international trade and prevent access to more lucrative markets. In addition, such events often have concomitant disastrous knock-on effects on closely linked industries and activities. Livelihood strategies driven by poverty and desperation that contribute to pollution hotspots, and the incubation of microbes and increased distribution of insect vectors due to climatic changes have a growing effect on both human and animal disease outbreaks. The poor often bear a disproportionately high share of the burden of (zoonotic) disease because of their close contact with livestock in unsanitary conditions. We are more in contact with animals than ever before, and livestock and wildlife are more in contact with each other. It is thus time to acknowledge the degree to which our health is connected to the health of animals and the environment.

The challenges

With global population projected to reach 9.6 billion in 2050, the livestock sector's role in providing high value food will continue to increase. At the same time, the natural resources that sustain agriculture, such as land and water, are becoming scarcer and are increasingly threatened by degradation and climate change. Climate change, changing ecologies, increasing travel and trade, and the coexistence of traditional and modern livestock production, are also growing animal health risks. How can we address these challenges?

First, we need to seize every opportunity to reduce poverty and stabilise livelihoods through livestock. Better access to productive resources, combined with services and innovation, can provide viable and inclusive growth enabling the poor to participate in growing markets or take up opportunities outside the livestock sector. Offered more income alternatives, many smallholders and pastoralists have chosen to exit the livestock sector, while others will continue to keep livestock for subsistence needs. Still, large numbers of them manage to intensify and commercialise their operation, as demonstrated by successful small-scale dairy development in South Asia and East Africa, for example.

Second, there is a need for inclusive approaches to managing disease threats at the animal-human-environment interface that involve producers at every level in the development and implementation of animal-disease and food-safety programmes.

Third, we need to improve the efficiency of the use of natural resources. FAO's analysis shows that there are huge efficiency gaps which can be profitably bridged using existing technology. Current productivity is still very low in many parts of the world. Incentives are needed to induce livestock keepers and resource managers to adopt better practices. Innovation and technology adaptation play a large role in making livestock more resource-efficient. Preferably, livestock production should be based on materials not competing with direct use as food.

Fourth, the potential of livestock to contribute to the protection of natural resources is huge and much underutilised. Climate gas emissions can be reduced substantially, and grasslands can sequester carbon, provide water resources and enhance biodiversity. Exploiting these opportunities can also provide new income to smallholders and pastoralists. Livestock can be a powerful tool in climate change adaptation, too. Through its capacity to turn vast amounts of low value resources and agricultural and food industry waste into desired products, and through its flexibility, by contracting and expanding, and by geographical shifts, the livestock sector provides an important buffer in global and country food systems. As we have entered a period of accelerating climate change, such capacity will be even more important.

The Global Agenda for Sustainable Livestock

In pursuing sustainability in the livestock sector, we need to recognise the different demands and expectations placed on it and the vast diversity of livestock systems world-wide. The multiple social, environmental and health aspects of sector development need to be dealt with in a dynamic, integrated and inter-disciplinary manner. Given the size and complexity of the task, joining forces is a necessity. FAO and its partners are, therefore, working together in new ways to address these challenges, for example through FAO's leading role in the Global Agenda for Sustainable Livestock.

The Agenda partnership unites the forces of the public and private sectors, producers, research and academic institutions, NGOs, social movements, and community-based organisations. The Agenda builds consensus on the path towards sustainability and catalyses coherent and collective practice change by (i) building relevant, co-constructed and accessible evidence; (ii) engaging stakeholders in dialogue to build common understanding and joint action; (iii) developing innovative approaches and solutions; and (iv) formulating tools and levers to enable and incentivise changes in food and agricultural systems.

The partnership (**www.livestock-dialogue.org**), built jointly from 2010, has identified common ground and increased global awareness on the development issues underlying sustainable livestock sector development.

Finding solutions for the sector to produce more, from less, in ways that benefit all, requires the integration of perspectives across scales and actors and a focus on incentives and innovation for practice change. Sustainable development depends on it.

Photo: P. Hiernaux

Zebu cattle corralled in the stubbles of a millet field during the dry season in western Niger. The calves have just been released for their morning suckling.

Livestock: recyclers that promote the sustainability of smallholder farms

Livestock are kept for a wide range of purposes in Africa, and there is considerable diversity in animal husbandry. Among the most important advantages in keeping animals is their contribution to maintaining and even improving soil fertility. Furthermore, animal husbandry offers economic, social and cultural benefits. However, the authors also look at the constraints that smallholders face in livestock husbandry.

Smallholder agriculture in the dry tropics of Africa is highly diversified in terms of farm assets and production systems. The crops include staple such as millet, sorghum, maize and cowpea, also associated with cash crops such as groundnut and cotton. The cropping practices range from hand cultivation to the use of animal traction, with mechanisation remaining exceptional (water pumps, cereal threshing). Family labour predominates and is organised at a range of levels from nuclear to extended family and to community, and is more or less tightly structured by gender and age. Wage labour is infrequent, but it is increasing alongside a diversity of mutual aid, sharing and entrustment institutions. If communal institutions dominate family access to natural resources with rights to crop instead of property titles, the regulations of these rights, their being shared among families and transmission between generations largely differ between regions and states. Yet livestock husbandry adds a whole dimension to this diversity by its impact on the farming system, its productivity and its sustainability. Livestock husbandry itself is extremely diversified depending on the species and breeds reared, the number of animals, the commodity targeted (meat, milk, draft) and also the options selected to feed or graze the animals.

In association with cropping, livestock husbandry is either 'agro-pastoral', with relatively large breeding herds fed by grazing, or 'mixed-farming' in which a few animals are reared in the farm compound either for fattening, for draft or dairy (see also Box on page 10).

In **agro-pastoral systems**, the reproduction goal implies relatively large herds mainly composed of females (75-85 per cent, and 50 per cent adult females). Because of the duration of the reproduction cycle and the reproductive female careers, livestock breeding in agro-pastoral system is organised in the long term. The herd size and the feeding of livestock by grazing entail the use of communal lands outside farmlands and, most often, seasonal moves of herds away from farmlands in regional, sometimes cross-border, transhumance.

In **mixed-farming systems**, the number of animals can be limited to just a few units, depending on the family investment capacity. And livestock can be reared for short periods, such as a few months for sheep or goat fattening, depending on market prices (animals, fodder), family labour availability and need for cash. Yet, livestock may also be kept longer, for draft (donkey, oxen, camels) or for commercial dairy farming.

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Photo: P. Hiernaux

Fattening a few sheep and goats in the backyard in mixed crop-livestock systems in western Niger.

Improving soil fertility with livestock husbandry

Whatever the farming system, livestock recycle a large fraction of the ingested feed as faeces and urine, albeit to a varying degree depending on the nutritive quality of the feed itself, the season and management. With high-quality feed, such as during wet season grazing, about 40 per cent of the feed intake is excreted as faeces, with the rate rising up to 60 per cent with low-quality feed, e.g. during late dry-season grazing. The share of nutrients recycled by livestock is even larger, often accounting for more than 80 per cent of the nutrient intake. There are nuances however, depending on breeds and animal physiological status. Lactating females, for example, are recycling less as they destine nutrients, especially protein, calcium, phosphate and sodium, to their offspring through milk. Most nutrients are recycled via faeces, but about half of the nitrogen is recycled in faeces and half in urine, as urea. Potassium and sodium are abundant in urine, conferring its elevated pH.

Agro-pastoral systems and mixed farming differ by the spatial distribution of the livestock excretions and by their management. Because livestock are grazing locally and away from the community lands during transhumance, about half of the excretions in agro-pastoral systems are deposited along the grazing orbits in rangelands, fallows and stubbles. Only the other half, occurring when livestock are resting by the water points, in yards, camps or corrals is managed by the agro-pastoralist to amend cropland soil fertility. This is done either by harvesting manure in the resting places, transporting and applying it manually in the field or direct deposition in the field by corralled livestock.

In addition to recycling nutrients, grazing livestock also impacts the agro-ecosystem by trampling. In the dry season, trampling mechanically transfers standing straws into litter, and then fragments and buries the litter into topsoil organic material. Both processes concur to speed up organic matter decomposition and, together with excretions, enhance soil biotic activity (termites, microbes, fungi).

In mixed farming systems, feeding livestock fodder crops (cowpea, groundnut haulms), crop residues (cereal stalks and brans) and agro-industrial by-products (cotton seed, groundnut or sesame cakes), is a way to value these products and recycle their organic matter and nutrients on the farm. All excretions are deposited in the barn, pen or yard where livestock are kept, and the resulting manure is harvested, cart-transported and hand-applied to the crop field.

Whatever the production system, the balances of the organic matter and nutrient fluxes due to livestock are a challenge to assess because of livestock mobility and rangeland communal management in agro-pastoralism, and because of multiple fodder inputs in mixed farming. Attempts have been made to assess these balances over a one-year cycle at a range of scales from farm to regions, highlighting contrasted balances between fields, landscape units and farms depending on livestock management. However, these balances do not account for trampling, the enhanced biological activity of the soils or the secondary effects of livestock grazing on soil erosion and burning risk attenuation.

The ways by which livestock recycle organic matter and nutrients in the agro-ecosystem differ between farming systems, but in all cases they result in a concentration of nutrients in fields selected by the farmer to have a higher soil fertility status: the ma-

Agro-pastoralism. Livestock husbandry is qualified 'pastoral' when livestock are fed mostly by grazing commonly managed rangelands, fallows, stubbles or browsing bushes and shrubs, and when the main goal is to produce young animals, among which most of the male are sold young while females are kept in the herd to reproduce and eventually provide some milk. If pastoral husbandry is associated to cropping, the resulting farming system is qualified 'agro-pastoral'.

Mixed farming. When grazing is not the major source of animal nutrition, livestock being fed harvested fodder and supplement feed at a barn or in a yard, and when reproduction is not the major goal, there are a number of livestock husbandry systems that altogether could be qualified of 'opportunistic' as they all are tightly market-oriented. This includes animal fattening (most often, young males bought on the market to be sold back after a few months, or else culled oxen or old females), draft animals, and some dairy cows. If opportunistic husbandry is associated to cropping, the resulting farming system is qualified 'mixed-farming'.

nured fields that often extend next to the villages or camps. The highest fertility of these fields is taken advantage of to raise and secure staple production (short cycle cereals) and to diversify production with more demanding cash crops (groundnut, cotton, sesame).

The economic, social and cultural benefit

Being nutrient recyclers and major agents in soil fertility enhancing is not the only, nor perceived by farmers as the first, role of livestock in smallholder farming systems. The animal production, being dairy products or meat, as animals sold on the market, and the services of draft animals for cart pulling or soil tilling (ploughing, weeding), are viewed as the prime benefits. In addition, herds are assets whose large capital values are determinant for the social and economic status of the farmers. Selling part of that capital provides cash to pay for taxes, school fees, and family daily needs. It also allows investments in farming equipment and off-farm activities such as trade and transport. Unlike crops, which are tied to a highly seasonal calendar in the dry tropics, livestock husbandry is a year-round occupation associating daily tasks (care, milking, herding, feeding and watering) to more seasonal (transhumance) and occasional ones (curing, selling). These tasks all require specialised expertise that altogether supports cultural values shared within the large social web of the pastoralists, agro-pastoralists, mixed farmers and the other professions of the livestock sector.

To conclude: what constrains livestock development in smallholder farms?

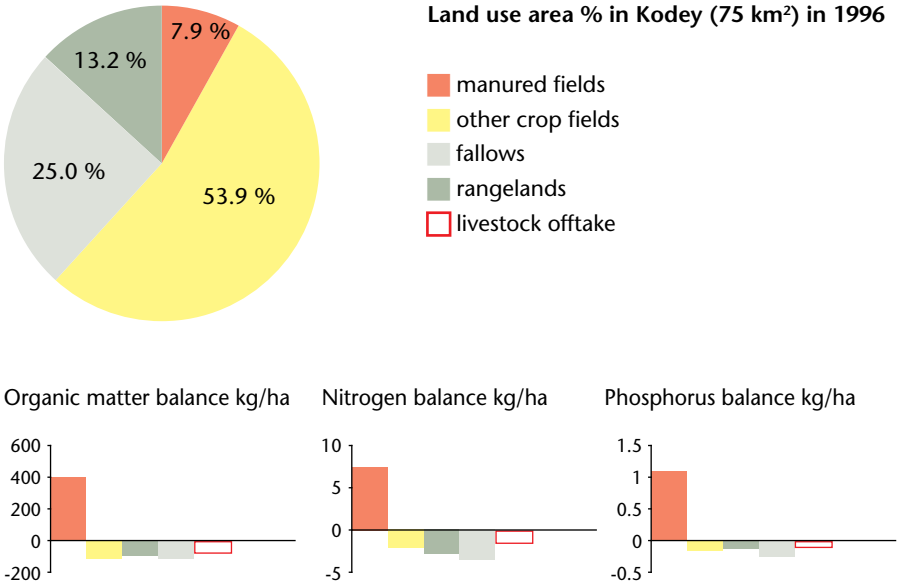
Livestock husbandry offers many options to strengthen farming system sustainability by enhancing soil productivity and providing high-value products and services, and it adds a whole dimension to farm diversification. So one could wonder what impedes or limits the livestock development of smallholder farms. While lacks in the capital needed to start, the labour availability within family, or the husbandry skills can deter some farmers from livestock husbandry, the main constraint that smallholders are facing is year-round access to good quality feed for livestock. In agro-pastoral farms, feed access is achieved by optimising the local and regional mobility of grazing livestock to adapt to the spatial heterogeneity and seasonal changes in rangeland resources. Given the historical expansion of land cropped, institutional restrictions on the moves of livestock and land tenure changes towards privatisation of the land, livestock access to grazing resources and capacity to move have to be secured. In mixed-farming husbandry, there is a need to boost fodder crop production and facilitate farmer access to high quality agro-industrial feeds on the market. Thus, the ways to solve the feed constraint differ between production systems. Yet, this should not hide the functional and commercial interrelations between agro-pastoralism (providing young animals) and mixed-farming (providing dry season grazing, agro-industrial by-products).

References and sources for further reading: ➤ **www.rural21.com**

Corralling livestock practice in western Niger

Herds are corralled during resting time between the evening and morning milking (some of the cattle herds go on night grazing for a few hours in the meantime). Corrals are not fenced, but animals are tied to poles stuck in the sandy soil, 4x4 m apart for cattle and 2x2 m apart for small ruminants. They are located on fallows during the cropping seasons and on croplands during the dry season, and they are moved every two to four weeks, corresponding to the annual manure application of 12 to 24 t dry matter (DM)/ha over 0.04 ha per cattle and 0.01 ha per small ruminant. One advantage of corralling is that urine is also captured. Even if a large fraction of the nitrogen from urine is lost by volatilisation, urine deposition has a specific contribution to soil fertility by bringing potassium and enhancing soil pH.

Organic matter, nitrogen and phosphorus annual balances calculated at the village territory scale based on livestock offtake, feed intake and excretion deposition monitored over a year cycle



Tropical forage-based systems for climate-smart livestock production in Latin America

Tropical forage grasses and legumes as key components of sustainable crop-livestock systems in Latin America and the Caribbean have major implications for improving food security, alleviating poverty, restoring degraded lands and mitigating climate change. Climate-smart tropical forage crops can improve the livestock productivity of smallholder farming systems and break the cycle of poverty and resource degradation. Sustainable intensification of forage-based systems contributes to better human nutrition, increases farm incomes, raises soil carbon accumulation and reduces greenhouse gas emissions.

Agricultural development in Latin America and the Caribbean (LAC) depends on how effectively the region can address a number of challenges. Climate change affects the region as a whole, but particularly Central America and the Caribbean (CAC). This is mainly due to natural resource degradation, which has made the region especially vulnerable to changes in rainfall patterns, higher temperatures and higher incidence of natural phenomena such as hurricanes and droughts. Sustainable intensification of crop and livestock production with a natural resource management focus is likely to be the best way to confront climate change, reverse land degradation, improve food and nutritional security and alleviate poverty of smallholder farmers in LAC. Climate change predictions are expected to have far-reaching consequences for livestock production in LAC, mainly via (i) increased frequency of drought in some regions and excess seasonal rainfall in other regions, with negative impacts on native and introduced forage productivity; and (ii) heat stress on animals, reducing the rate of animal feed intake, causing poor performance growth and reducing animal fertility.

Livestock have served the poor in LAC as a social safety net, providing insurance or a "bank account" for times of need. Sustainable intensification of livestock production can provide regular food and income for improved livelihoods. There are approximately 450 million hectares of native and introduced pastures in tropical LAC. A major constraint to livestock production is the quantity and quality of forage production as a key feed source in ruminant systems. Overgrazing and a lack of suitable forage options that are better adapted to biotic (pests and diseases) and abiotic (edaphic and climatic) stress factors contribute to low productivity. Improper management (e.g., no fertiliser application and overgrazing) of pastures lead to soil nutrient depletion and pasture degradation, and limit livestock production. Improving pasture quality and productivity offers a readily available means of increasing food production and vitally needed protein production.

Production per animal unit in tropical areas of LAC is much less than in temperate regions. Increasing pasture productivity could help materially increase animal production. Easy access to high-quality forages and/or improved pasture management are crucial entry points for enhancing animal production and animal health, and it increases viability of genetic improvement of livestock. The sowing of better quality forages and better pasture management can improve forage digestibility and nutrient quality, resulting in faster animal growth rates, higher milk production and earlier age at first calving. Better nutrition can also increase cow fertility rates, and reduce mortality rates of calves and mature animals, thus improving animal and herd performance.

At least two alternatives exist for improving forage production in the LAC. One is to improve production of permanent pastures, and the other is to establish and maintain high yielding cultivated species on arable or potentially arable land in the three major agro-ecosystems of the region (savannahs, hillsides and forest margins). A third option would be a combination of the two. The potential for forage production in tropical regions is tremendous for both intensive and extensive types of production, although production costs are higher with proper grazing management technologies and the economic alternatives must be carefully considered. This article highlights the importance of tropical forage-based systems for climate-smart livestock production in LAC and presents the concept of LivestockPlus to stimulate interest and research in tropical forage production for the benefit of both agriculture and the environment.

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Development of climate-smart tropical forages

Forage grasses and legumes are complex crops, and their value for agriculture must be assessed in terms of the quantity and quality of downstream livestock products (traditionally milk and meat). In LAC, superior *Brachiaria* grasses have been widely adopted with large economic benefits. Experiences from Colombia and Brazil indicate that these pastures make a significant contribution to farmers' incomes by increasing animal productivity by five to ten times over native savannah vegetation. In Brazil, where about 99 million hectares are planted with *Brachiaria* grasses, annual benefits are believed to be as large as 4 billion US dollars (USD), while in Colombia, they are thought to exceed 1 billion USD. Estimates for Central America suggest that adoption of *Brachiaria* grasses generates an additional value of about 1 billion USD in one year, with 80 per cent of the gains accruing to the beef and 20 per cent to the milk industries.

The adaptation of *Brachiaria* grasses to low-fertility soils has contributed to their use for extensive, low-input pastures but also for intensively managed pastures. Although rotation of annual cropping with grazed pasture is not commonly practised, despite many potential benefits for both crops and forages, it is increasingly becoming an option for farmers in tropical America, above all in Brazil.

From *Brachiaria* breeding efforts at CIAT (Centro Internacional de Agricultura Tropical/ International Center for Tropical Agriculture), three commercial cultivars have so far been released: Mulato, Mulato 2, and Cayman. These three superior *Brachiaria*-bred cultivars combine high productivity, nutritional quality, resistance to spittlebugs, dry season tolerance, and adaptation to infertile acid soils (see photo below). But neither Mulato nor Mulato 2 are tolerant to waterlogging conditions. Recently, CIAT initiated efforts to breed for superior *Brachiaria humidicola* hybrids. These hybrids are required to diversify pastures in poorly drained or occasionally waterlogged soils that are estimated to cover about 7 per cent of the Cerrados (savannah) region of Central Brazil (approx. 17 million hectares) and major cattle production regions in the Amazon and the Atlantic regions of Central America. This work has been partially supported by the Ministry of Agriculture and Rural Development of Colombia and the private sector (Tropical Seeds; Dow AgroSciences).

Deep rooted *Brachiaria* grasses accumulate large amounts of carbon in deeper soil layers and contribute as such to mitigation of climate change. Forages can also contribute to the reduction of greenhouse gas emissions: feeding high quality forage grasses reduces methane emissions from animals per unit livestock product, whereas some *Brachiaria* grasses (such as *B. humidicola* CIAT 679) suppress soil nitrification by releasing from its roots a powerful nitrification inhibitor named brachialactone, thereby reducing emissions of nitrous oxide. This phenomenon is known as Biological Nitrification Inhibition (BNI). If a *Brachiaria* pasture with high BNI activity were to carry over to a subsequent crop, it might improve the crop's nitrogen (N) use efficiency and therefore its economy, especially for crops fertilised with substantial amounts of N.

To begin reaping the environmental and economic benefits of this improved grass on a large scale, CIAT and its partners are working on several fronts. Forage grass breeders are developing superior *B. humidicola* hybrids and seeking to accelerate hybrid selection through the use of molecular markers. At the same time, scientists together with smallholder farmers in Colombia and Nicaragua are evaluating already available *B. humidicola* hybrids and learning how to optimally integrate them into crop-livestock systems (see Box on page 15). In addition, researchers are using advanced simulation models and economic analysis to project where the new hybrids can be profitably introduced. The scope for integrating these materials into forage-based systems is quite large, especially in LAC, where various *Brachiaria* grass species are already the main feed resource for livestock production. This BNI technology could result in cropping systems with low nitrification and low nitrous oxide emissions thus decreasing N-input requirements for the subsequent annual crops and make agro-pastoral systems more productive and ecologically sustainable. Since *B. humidicola* hybrids offer the advantage of performing well

Photo: John W. Miles/CIAT

Cattle grazing on improved Brachiaria grass pasture.

on infertile soils, they should appeal to large numbers of smallholders across LAC. This work has been conducted in collaboration with JIRCAS, Japan and is also supported by Germany's Federal Ministry for Economic Cooperation and Development (BMZ).

Most herbaceous (e.g., *Arachis, Stylosanthes, Centrosema*), shrub (e.g., *Cratylia*) and tree (e.g., *Leucaena*) forage legumes have the ability to contribute N to the system and have high protein contents. These are deep-rooted to tolerate drought and give the ability to scavenge for nutrients in infertile soils. Tropical forage legumes not only provide high-quality animal feed but also enhance soil fertility, improve soil structure and water infiltration, increase soil carbon accumulation, favour soil biological activity, and contribute to weed control and soil conservation. Grass-legume pastures need no N fertiliser, thus offering both economic and environmental benefits. Legume-based pastures and, especially, cover crops/green manure can also increase the yield of subsequent crops. However, adoption of legumes for livestock production has been rather poor in the past and their dissemination is expected to continue at a low level unless economic incentives increase.

The LivestockPlus concept for climate-smart livestock production

To articulate how improved forages can lead to the sustainable intensification of mixed crop-forage-livestock-tree systems in the tropics and subtropics, CIAT and its partners have developed the LivestockPlus concept (see Figure), which comprehensively recognises multiple social, economic and environmental objectives. While minimising trade-offs, LivestockPlus emphasises synergistic interactions between people, soils, plants, animals, and the environment. The LivestockPlus concept aims to improve agricultural productivity based on four principles:

1) Selected sown grasses and legumes, if properly managed, are more productive than native or naturalised forages, and produce higher quality feed while allowing the release of land for alternative uses with low environmental footprints.

2) Well-managed sown grasses and legumes in combination with crop residues improve resource-use efficiency at farm level and produce more milk and meat, particularly in the dry season.

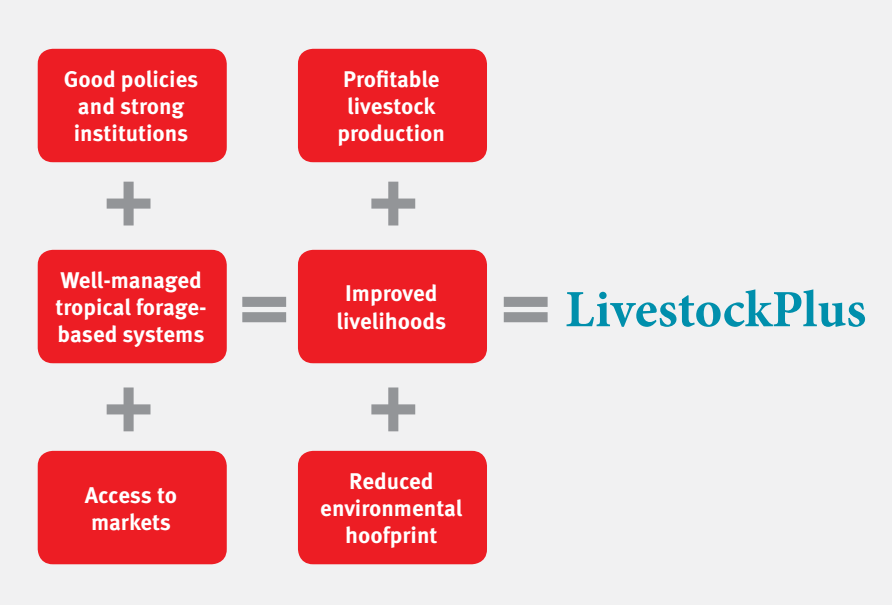
3) Sown grasses and legumes, especially when integrated with crops and trees under proper management, enhance system productivity, resilience and livelihoods. They also generate other ecosystem services, thereby reducing the environmental footprint per unit livestock product.

4) Multiple actions are needed to create enabling conditions essential for the adoption and widespread use of improved forage-based systems, including genetic improvement of livestock to match improved feeding, changes to regional and national policies along with increases of human and social capital.

Future challenges

The LivestockPlus concept proposes a practical pathway towards the goal of producing more agricultural products, with attention to livelihoods and ecosystem services for current and future generations. Increasing consumer demand for livestock products can and should be met by increasing productivity within the same region, mostly in the tropics and subtropics. Although livestock productivity could be increased using grain-based feeds, we favour intensification through forage-based systems based on goals of eco-efficiency, i.e., economic viability, environmental sustainability and social equity. To spark greater interest in and adoption of improved forages, however, the benefits of LivestockPlus need to be communicated to the global community. LivestockPlus seeks to double animal production on 50 per cent less land in the next ten years in some regions of a few countries where policies are favourable for adoption, freeing land for sustainable crop production, reduced deforestation and providing ecosystem services. Applying these interventions in resilient crop and livestock value chains should ensure economic gain and reduce poverty.

The LivestockPlus concept



Integration of forages to improve crop-livestock production – experience from Nicaragua

Photo: Aracely Castro/CIAT

Adoption of Brachiaria grass by smallholder farmers in the Condega region of Nicaragua.

Participatory action research with smallholder farmers from communities located in Somotillo and Condega municipalities in Nicaragua compared different treatments for improved systems and components (varieties of maize and bean in agroforestry systems and a forage option in a silvopastoral system) and their impacts on crop yields, forage and animal production parameters (grass biomass and milk yields) and ecosystem services (soil quality, carbon accumulation, soil erosion, biodiversity conservation). The approach involved farmers directly in the process, providing an opportunity to learn by doing, and allowing them to observe changes and benefits first-hand. This has also motivated farmers who were not participating directly in the project to adopt components or management (systems) or even the whole integrated crop-livestock farming system (agroforestry + silvopastoral) at an early stage.

Through field days with farmers, technicians, researchers, and representatives from the municipalities of Condega and Somotillo, research results and socioeconomic surveys have been presented and discussed with different stakeholders. The work, supported by the Austrian Development Agency (ADA), also facilitated visits from 100 farmers and technicians from other regions in Nicaragua, allowing to scale out the initiative to a broader range of beneficiaries. Validation of recommendation domains through workshops and ground truthing was done to facilitate further dissemination in other sites of Nicaragua that are suitable for adaptation and adoption of the integrated crop-livestock farming system. The project's integration of improved food crop and forage options to boost productivity and profitability, and particularly to enhance milk production during the dry season, has strongly encouraged early adoption of these alternatives by farmers, allowing them to see quick benefits as they could also recognise potential long-term environmental improvements.

Another innovative element of the project is the identification of socio-cultural and socioeconomic factors that can drive the adoption of eco-efficient crop-livestock systems. Establishing a collaborative learning community among farmers, women, and young people has been crucial, not only as part of the project's on-going research, but also to strengthen the communities' ability to carry on the farming system on their own and share their acquired knowledge and new experiences with others.

Pasture management in Central Asia – regional learning for reform

The former Soviet Central Asian republics have undergone de-intensification of their livestock sectors, resulting in an increased reliance on natural pastures. Property rights systems are key to the sustainable management of this resource. However, as the authors demonstrate, it is not easy to implement the respective reform processes.

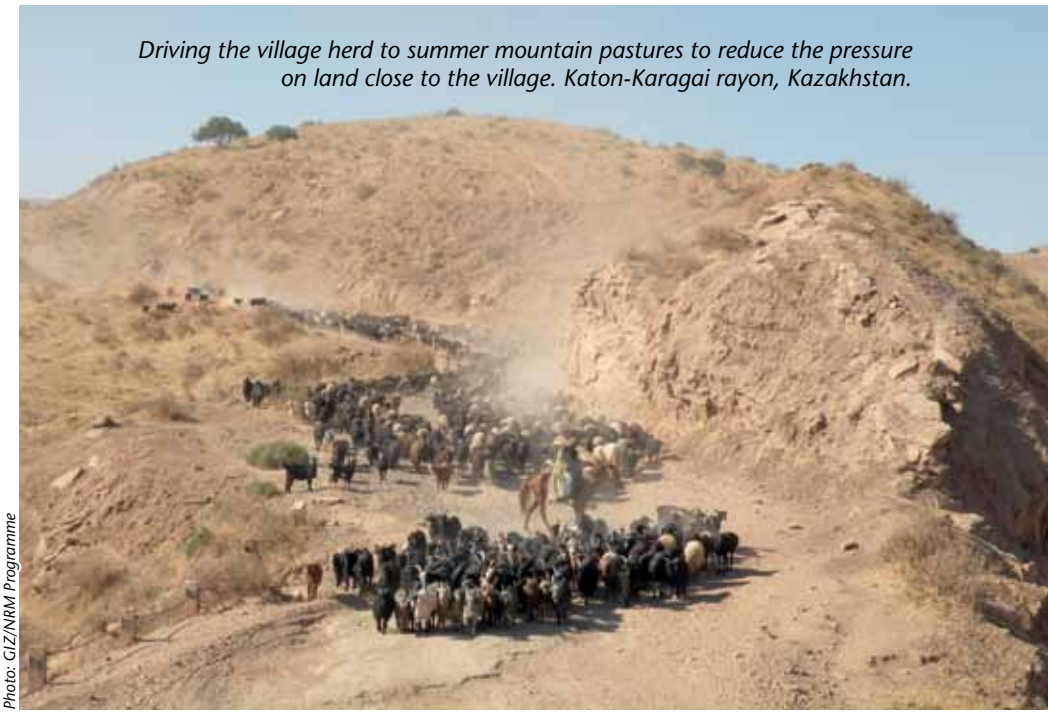
Central Asia receives little attention from the development community although, at 3.9 million km², its area is close to that of the European Union. The region's forests, soils and pasturelands are under pressure from rising rural populations whose dependence on those resources has increased since the collapse of the Soviet Union. Globally important ecosystems are at risk, particularly in the face of climate change. While restoration programmes are expensive, improvements in management systems – although institutionally challenging – are relatively cheap. They may be particularly effective in the case of pastures, where resource use is highly uneven. However, the low priority given to sustainable and inclusive land management by governments represents a major barrier to reform processes.

Post-independence challenges

During the Soviet period, livestock movement between seasonal pastures, often using traditional migratory routes, was an important component of grazing systems. However, importation of subsidised winter feed meant that migrations could be less extensive than before, and allowed livestock numbers to reach historical highs. In the immediate aftermath of independence, feed imports ceased and irrigated land was turned over to crops for human consumption, resulting in a winter feed crisis. State-subsidised pasture improvement programmes such as fertilisation and seeding also came to an end. Livestock thus became highly dependent on natural pastures. Yet as the state system collapsed, transport costs soared and wells fell into disrepair – reducing the means to reach and use remote pastures. In some republics, livestock inventories fell sharply; economies of scale required for movement were lost, exacerbating the abandonment of remote pastures and concentration of livestock around settlements. The proportion of private animals increased – livestock ownership distributions became characterised by a small number of households with commercial flocks or herds, and a larger number owning fewer animals, often for subsistence. The latter households often participate in collective herding systems – pooling animals to cover the costs of shepherding and transport.

Property rights in the new Central Asia

At first, property rights governing access to pastures by the new private herders remained in a legal grey area; access was determined by former state farm boundaries, customary memory, and ownership of key infrastructure. As livestock inventories recovered, formal land tenure legislation was in-



Driving the village herd to summer mountain pastures to reduce the pressure on land close to the village. Katon-Karagai rayon, Kazakhstan.

Photo: GIZ/NRM Programme

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Photo: Public Fund CAMP Alatoo

Workshop on joint pasture management in Naryn, Kyrgyzstan.

creasingly applied to grazing lands. This legislation initially concerned land codes designed for arable land reform which emphasise individual forms of tenure. But as difficulties in the application of these laws to grazing lands became apparent, attention turned to the design of legislation specific to pastures. Debates arose on whether pasture should be allocated to individuals by leasehold or privatisation, or managed as a common property resource. Some policy makers take the view that only long-term individualised access rights can encourage sustainable management and investment, whilst others fear that such rights lead to fragmentation of grazing systems, a reduction in livestock mobility and the loss of access to pastures by poorer households.

Common pasture management – the Kyrgyz example

In Kyrgyzstan a pasture leasing system was initially introduced. Conflicts over pasture between collective herding groups (unable to take out contracts) and leaseholders, combined with the high transaction costs associated with the leasing system, led to its abolishment in 2009. A new pasture law, elaborated with the support of the World Bank and including experiences based on pilot activities conducted through the GIZ Regional Programme (see Box) introduced principles of common property resource management. Pastures are now allocated to village governments and managed by Pasture Users Associations (PUA) through annual sale of pasture tickets. Concerns about the new law include the administrative capacity of PUAs; lack of clarity regarding their responsibilities; and problems of inter-sectoral cooperation (for example with the forestry sector). Initial observations suggested that the PUA are not as inclusive as originally intended: official protocols for PUA establishment were sometimes replaced by less transparent procedures dominated by village governments. Information asymmetries initially led to a lack of participation of some herding households. International development agencies and national NGOs currently support capacity building of PUAs, for planning and monitoring of a sustainable pasture management and combating degradation of the resource, with the GIZ Regional Programme playing a coordination role.

On the positive side, the 2009 law is the first in Central Asia to enshrine the principle of common property for pastures; it introduces payment calculated per head of livestock rather than on a hectare basis and preserves the ecological integrity of grazing systems. In the other republics, the situation is quite different (see Box on page 18), and for these, Kyrgyzstan is an important test case to observe. Here, the GIZ programme employs

The GIZ Regional Programme on Sustainable Use of Natural Resources in Central Asia

A five-year period of pilot projects to combat desertification in 2008 led to the establishment of the GIZ Regional Programme on Sustainable Use of Natural Resources in Central Asia, implemented on behalf of the Federal Ministry for Economic Cooperation and Development (BMZ). In 2013 the European Union launched the regional FLERMONECA project – Forest and Biodiversity Governance including Environmental Monitoring, also implemented in the framework of the Regional Programme. The project facilitates dialogue between Central Asian policy makers in order to promote reform for sustainable management of forest, pasture and wildlife resources.

The Regional Programme adapted the classical policy cycle for development projects to take account of transformation processes characteristic of Central Asian former Soviet countries. Since there are few examples of land management mechanisms involving local users in Central Asia, piloting of possible models is key to the success of reforms. Once such models are elaborated, confidence concerning their transferability must be gained. Only then can reform concepts and a legal framework be developed. In parallel, policy dialogue and donor co-ordination are necessary to attract investments in the reformed framework and to disseminate and mainstream new land use models. The fruits of these reforms are then used to inform pilot activities and reform processes in other Central Asian countries.

exposure tours, policy dialogue and expert missions to support learning for national reform processes.

Mutual learning and intersectoral co-operation is key

The current discussions on pastoral tenure reform in Central Asia reflect questions which have been debated in other parts of the world for many years. Much has been written on the impacts of pasture reform on land degradation in Inner Mongolia and Tibet, sub-division of tribal lands in Africa and on the tensions between public and private range management in the USA. Yet this experience is rarely discussed in Central Asia, where the same issues are sources of conflict at the local level and political argument at the national level. In order to benefit from experiences from outside Central Asia, the EU FLERMONECA project (see Box on page 17), the International Fund for Agricultural Development (IFAD) and other development partners supported a practitioners' conference on pasture management reform in Bishkek/Kyrgyzstan in November 2014 to bring worldwide examples of property rights systems which promote environmental sustainability, economic efficiency and equality of access, to a Central Asian audience. To tackle the low political priority given to reform processes, the Regional Programme supports the Economics of Land Degradation (ELD) initiative to support case studies valuing the economic costs of action vs. costs of non-action, i.e. further degradation of pastures. The intention is to provide stronger arguments for sustainable pasture management to relevant political decision-makers.

A major challenge for the future remains to overcome divisions between agencies responsible for forestry and pasture management and move towards a more integrated system of land management. In this regard, a pilot has been launched in the framework of the Energy and Climate Fund Programme "Biodiversity Conservation and Poverty Reduction through Community-based Management of Walnut Forests in Southern Kyrgyzstan".

References and sources for further reading: ➤ **www.rural21.com**

Population (million) and principle physical features of Central Asia (boundaries: Global Administrative Areas)

Basemap: National Geographic

Pastoral property rights in the other four republics

The Land Code of **Tajikistan** allows pastures to be registered to individuals for long-term or permanent heritable use. This led to annexation of certain pastures into private farms, whilst the majority of animals remained in households with no formal access to grazing lands. The 2013 pasture law makes arrangements for allocation of pastures to users associations, but forms of exclusive property right persist, leading to conflicts of interest. The GIZ regional programme supports a coordination platform bringing together state bodies, international development agencies and NGOs for the development of by-laws and implementation regulations for the new pasture law.

In **Kazakhstan**, pastures may be leased from the state and both the majority of livestock and area under lease are held in registered private farms. Areas around villages are available to all for common use, although these are small and often heavily grazed. Access to pastures outside settlements may be problematic for smaller herds who are unable to bear costs of labour, infrastructure and pasture registration. Up to 2011 the GIZ Regional Programme and UNDP supported pilot projects on seasonal rotational grazing and fodder production on rehabilitated fallow land as well as strategy development for sustainable pasture management, used for a government livestock development programme.

In **Uzbekistan**, most livestock are owned by private households, whilst the bulk of pastures are held by state farming enterprises with whom these households must negotiate access. Up to 2014, the Regional Programme supported a pilot project on improved pasture management, and it supports economic valuation of pasture ecosystem services.

In **Turkmenistan**, pastures are held in state-owned farmers associations. State animals are managed by private individuals according to a leasehold arrangement which provides both access to pasture and the opportunity to accumulate private stock. Associations also informally allocate pastures for use by non-leaseholding residents. The GIZ Regional Programme is currently supporting a parliamentary working group to elaborate a pasture law covering access by all types of user, starting with stakeholder consultation in the field.

A young Dinka protecting his family's Zebu cattle against cattle raiders with an AK-47 rifle.

Photo: J. Boethling

Pastoralism and conflict – two sides of a coin?

Pastoralism – the predominant form of livestock keeping in the Horn of Africa – has always been a source of disputes and tensions in the region. So it is maybe no coincidence that precisely those countries with the largest cattle and camel herds should be the ones that have been suffering from prolonged armed conflict for years. This article takes a look at the closely interwoven aspects influencing conflicts in the Horn of Africa in general and South Sudan more specifically.

More than 20 million people live as nomadic pastoralists in the Horn of Africa. Pastoralism is a form of animal husbandry that is ideally suited to the dry, desert-like climate and has proved its worth in these areas for centuries. However, this traditional mode of life is becoming increasingly endangered by a wide range of developments. Moreover, owing to political marginalisation and poor accessibility, pastoralists often belong to the poorest sections of the population. Their situation is aggravated by armed conflicts that have become more frequent over the last few years.

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The dispute over the natural resources

The link between pastoralist livelihoods and potential conflict over natural resources in particular is multilayered. More than ever, secure access to grazing land and water facilities has become one of the main causes for tension in the Horn of Africa during the last decade. As pastoralism is the predominant form of livestock keeping, this entails a varying degree of mobility for the search of adequate pastures and access to water. In regions where access to grazing areas is increasingly restricted due to e.g. the extension of agricultural land, urbanisation or conservation areas, the use of land by pastoralists can cause severe tensions. Basically, the relationship between nomads and sedentary farmers is of a more symbiotic nature. After all, the droppings of the herds act as fertiliser for the already harvested fields. And the animals can feed on the crop residues. But where this temporal coincidence is not given because, for example, arable land is developing in what used to be pastureland, livestock is increasingly driven onto fields that have not yet been harvested.

The primary causes of disputes or tensions between pastoralists (and also between farmers and pastoralists) are access to water points/grazing land, stock theft and livestock trespass. Aggravating factors such as increasing climate variability/droughts, population growth, increasing poverty, but also tribal conflicts and the closure of stock routes or dry season pastures due to conflict or infrastructure development as well as the proliferation of automatic weapons have led to an escalation of conflict dynamics in the last few years.

From "redistributive" to "predatory" raiding

Also, some observers argue, there is a breakdown of the community

spirit, or reciprocity, between clans and tribes. In the past, traditional pastoral conflict was termed "redistributive raiding", and was subjected to strict rules (for instance, the killing of or violence against women and children was widely condemned). It was also predictable to some extent (e.g. restocking after droughts, a distinct situation between two clans). There was a degree of ritualisation involved in raiding; it had the blessing of the whole community, and elders would mediate or supervise the conflict. This, however, has changed in the last years, and "predatory raiding" orchestrated by individuals with criminal political or commercial intent is on the increase. Politically motivated conflict includes the killing of farmers, livestock owners or women and children, with no attempt at actually stealing or targeting livestock herds.

The effects of the conflicts on livestock and livestock owners are multiple and can entail direct loss/injury of livestock through looting or a "burnt earth policy". The limited access to water and food, and crowding of livestock in secure areas leads to a decreasing health status and weakening of the animals. Loss of animals, their livestock products, decreased mobility as well as, often, a loss of family members directly impacts on the livelihoods of affected people, with women often being disproportionally more affected.

In countries where national conflicts directly influence conflict dynamics at regional level, issues get increasingly complex – as for example in South Sudan.

A broken dream?

It is just a few years ago that rejoicing crowds of people took to the streets of Juba to celebrate the birth of the world's youngest nation. On the 9th July 2011, South Sudan gained independence, following decades of civil war. Almost three years on, the country is on the brink of a humanitarian disaster. The background to this is a vicious circle of inter-ethnic violence and brutal violations of human rights that started as a political power play between President Salva Kiir and former Vice-President Riek Machar. The conflict refuelled rivalries between the two largest ethnic groups in the country – Salva Kiir is from the Dinka, whereas Riek Machar belongs to the Nuer. As a result, according to figures released by the United Nations High Commissioner for Refugees (UNHCR), more than 1.5 million people are fleeing the conflict – either in the country itself, or they have sought refuge in neighbouring countries. Unrest has led to cropland no longer being tilled and pillaging of stored harvests. The UNHCR states that around 3.5 million people are now facing crisis or emergency levels of food insecurity; there are fears of a famine.

Livestock – a precious resource

With a population of approx. 8.2 million people and an estimated 30 million cattle, goats and sheep, South Sudan, a country nearly double the size of Germany, is among the regions with the greatest abundance of livestock. With an average 25 animals per capita, the country also has the largest livestock per capita ratio in Africa. More than 85 per cent of the population keep livestock. The vast majority of them are pastoralists, moving around the country in search of suitable pastureland depending on the season, and using traditional routes.

In this East African country, cattle play a key role in society. They provide social security, "money on hooves", are demanded as a dowry and are sacrificed during traditional rituals. The greater the herd, the more social prestige people enjoy. The animals are only slaughtered in emergencies or on special occasions, and unlike in other societies, desired breeding success is not oriented on the milk yield of animals but on the shape of the horns and the fur colour. At initiation, young Dinka men receive a bull that they care for and decorate and remain close to all its life. The name the young men are given after initiation refers to the fur of their bull. When cattle have acquired such a high cultural status, they become the cause of disputes and conflicts as well. This also includes the widespread custom of cattle rustling – which now unfortunately often ends in bloodshed because of the widespread availability of rapid-fire weapons. In addition, in some areas, mounting overgrazing is resulting in disputes over the valuable pastureland. However, it has to be mentioned that cattle do also play an important role in settling conflicts, for example as compensatory or deficiency payments.

The frontier drawn in 2011 crosses one of the most fertile and much sought regions of Sudan. It also cut through traditional routes of pastoral peoples. During the dry period, which lasts for several months, nomads from Arab tribes come from the north down to the southern pastures that get up to 600 mm of rain a year (in contrast with the 150 mm in the dry north). The Misseriyas' annual dry season migration alone takes some 50,000 herders and 1.2 million cattle from South Kordofan as far as Unity and Warrap states in South Sudan. But insecurity and conflicts have hindered the migration of cattle south, resulting in concentrations of livestock in border states and in some states to the north. Without adequate access to forage and water, pastoralists are forced to encroach on agricultural land, fuelling conflicts with affected farmers. The areas north of the border now are subject to severe overgrazing – and even an improvement of rangeland management practices to vertically enhance productivity of the grazing lands will not be enough to compensate for the lost areas. Only recently has the importance of livestock migration corridors been acknowledged. In the Blue Nile State of the Republic of Sudan for example, a demarcation and compensation process led to the re-opening of 109 km of livestock corridor in late 2013. The government, however, does not recognise the demarcations officially, and in some parts of the corridor, fees are demanded.

Jonglei is getting no peace

Jonglei is the largest South Sudanese state in the East of the country, and also one of its least developed. There are hardly more than 100 km of tarmac roads; during the rainy season, this remote area, with the provincial capital of Pibor, is completely inaccessible by land. During the last few years, Jonglei has again and again witnessed interethnic violence. In 2012, the Lou Nuer commited a massacre of the Murle tribe in which more than 3,000 people are said to have been killed. The reason for this was stolen cattle.

Hostilities that often already exist between the ethnic groups are being aggravated by political power struggles between the elites. This is also particularly the case between the Lou Nuer and the Dinka. Since both ethnic groups are agropastoralists, with a major share of the people earning their living with animal husbandry, destroying this basis as a strategy for the hostile groups to attack one another is, unfortunately, the order of the day. So cattle and pastoral structures are closely intermeshed with the dynamics of conflict. While they are often not the cause of conflicts, they do trigger recurrent hostilities. Additionally complicating factors include poor trust in justice mechanisms and local administration, poor infrastructure, food insecurity and inadequate access to water.

There can be no sustainable political solution to the conflict between Sudan and South Sudan as well as to the conflict within South Sudan without accommodating a viable future for pastoralists. And this is precisely what the activities of the organisation Vétérinaires Sans Frontières Germany (VSFG) set out from.

What is part of the problem is also part of the solution – the work of VSFG

Vétérinaires Sans Frontières Germany (VSFG) has been involved in projects in South Sudan and Sudan for more than 20 years – in the fields of animal health as well as in food security and peace building. Here, the organisation is supporting families and refugees affected by the civil war with direct and indirect animal health measures.

Animal health can be a crucial factor in conflict developments. If the animals die, it is not only the lives of people depending on them that are threatened. Another consequence is an increased incidence of livestock thefts, which in turn can further aggravate the conflict. Animal stocks in the region that have already been strongly decimated by the hostilities therefore need to be restored in order to strengthen the livelihoods of the people depending on animal husbandry, but also to counter renewed cycles of cattle rustling.

In a current project, VSFG has the opportunity to operate in the districts of Bor and Pibor in Jonglei, both of which are strongly affected by the civil war. Here, the association can draw on a network of former staff and animal health assistants that was previously developed over a number of years to thus reach out to people in remote areas as well. The planned measures include vaccinations and deworming as well as the training of Community Animal Health Workers (CAHWs), who are provided with a basic kit of medicaments and can treat the most common illnesses. The measures are to effectively support animal health and thus significantly reduce the mortality rate.

Thanks to the holistic approach applied in animal health and peace building, VSFG has already been able to achieve good results in other projects. For example, the association played a crucial role in the peace negotiations between various Dinka clans in Warrap State. A major conference was attended both by the Commissioners of three Counties and representatives of the Chiefs engaged in efforts to settle conflicts at state level, as well as by military officials and politicians. For the first time, young warriors had also been invited who live in the cattle camps and are responsible for livestock thefts. They have repeatedly questioned the authority of the traditional Chiefs. Young and old, respected women were present, too. Together, they called for an end to all hostilities, chanting their slogan "Akac akac" – "enough is enough".

For more information: ➤ **www.vsfg.org**

Celebrating together after signing the peace treaty.

Photo: VSFG

Linking poor livestock keepers to markets

The growing global demand for animal products also offers poor livestock keepers the opportunity to switch from the subsistence to the market economy. Our author gives an account of three approaches in the meat and dairy sector in Africa and Asia with their respective potentials and limitations – and also warns against possible negative effects.

An estimated one billion poor livestock keepers live in developing countries. About 600 million are found in South Asia, mostly in India. Sub-Saharan Africa has more than 300 million poor livestock keepers, mostly in East and West Africa, but also in the Southern and Central regions. Livestock keepers derive various benefits from their animals, starting with food (milk, meat, eggs) and services (draught). They also earn income when selling livestock or livestock products. Manure used as natural fertiliser is crucial for soil fertility management. Finally, livestock are used as savings and can be sold to get cash in case of an emergency, and in many setups, livestock also provide important social benefits.

Market orientation is low, with many livestock keepers operating at subsistence level with no or limited surplus to sell. On the other hand, demand for animal source foods is expected to increase annually by 2.8 per cent in Africa and 4.1 per cent in South Asia between 2007 and 2050, due to population growth, increased income and urbanisation, a phenomenon known as the Livestock Revolution. The question is therefore whether smallholder livestock keepers are going to meet the demand by increasing their productivity and being able to generate a surplus. Better off and larger-scale producers may be in a more favourable position to respond to this increase in demand, especially as consumers are increasingly demanding safer products. On the other hand, linking small-scale farmers to livestock markets not only makes economic sense, since they have been shown to have a comparative advantage in livestock production, but also addresses the issue of equity. This article first describes reasons why livestock keepers are weakly linked to markets. We then present some approaches that have been followed to strengthen livestock keepers' access to markets.

Why do livestock keepers not access markets?

Access to market refers to input and service markets on the one hand and output markets on the other. Although in some systems, livestock keepers are able to increase productivity, and therefore sale of outputs, using their own resources (e.g. land/labour), in most cases, farmers will need to purchase external inputs (like feed) or services (to maintain their animals' health) to generate a surplus. A value chain approach that looks at the various actors, from input and service providers to final consumers, is needed. Indeed, previous projects that focused on only one part of the value chain, for example production, have often failed as other bottlenecks along the value chains had not been considered at the time.

Reasons for low market orientation include unavailability of a reliable and/or profitable markets as well as low surplus, either because of low production or a high consumption level within the family unit. For any livestock keeper to invest resources, including her own family labour and land as well as financial resources, to generate a surplus, she must be able to sell her products at a price that is above production costs. Smallholders' market orientation has been reported as low, especially among pastoral communities (McPeak and Barrett, 2001). In areas suitable for dairy farming in East Africa, a survey conducted in 2009 shows that only half the cattle keepers sold milk on a regular basis. On the input side, the same survey data show that purchase of inputs was even less frequent: only 5 per cent of

Delivering milk to a collection centre in Tanga, Tanzania. Photo: ILRI

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dairy farmers in Rwanda bought dairy concentrates. The percentage was higher for Uganda (33 %) and Kenya (58 %). Purchase of fodder was even less frequent, with 5, 15 and 17 per cent of cattle keepers doing it on a regular basis in Uganda, Rwanda and Kenya respectively (EADD baseline reports 1 and 3, 2010).

In the past, some inputs and services like artificial insemination, veterinary and extension services were heavily subsidised, and therefore their use was relatively high, with a positive impact on productivity. Structural adjustment programmes in the 1980s meant that most governments had to cut on support to these productivity enhancement initiatives. The objective was that the private sector would move in and bridge the gaps. However, this is only happening in the more intensified, livestock-dense areas, where it will be profitable (Owano et al.). In other areas, in particular in the pastoral areas, such a development has not been observed much.

Photo: ILRI

Selling milk by the road in Tanzania.

Three approaches

Various approaches to link livestock keepers to markets have been followed, and in this article we look at three of them. The first two describe experiences linking farmers to local (national) markets, one based on collective action and the other on contract farming. The third example is about export markets.

Linking farmers using Producers Organisations – the power of collective action. Producers Organisations (PO) are at the heart of the hub approach, which is a mechanism to upgrade the value chain by facilitating market linkages. In situations where smallholder producers are scattered and produce low volumes, it is uneconomical for input and business service providers (e.g. feed inputs) and traders/ processors (e.g. milk traders and processors) to provide services to these farmers. A hub approach will start by identifying the organisational and institutional arrangement(s) required for farmers to get together (through, for example, a co-operative) and supporting the group in moving toward this desired state. At the same time, market agents are sensitised and supported to provide business linkages to the PO. By working with the private sector and building the capacity of producers to run and own their organisation, this approach aims at ensuring sustainability of the market linkages when project support ends. The value chain transformation is possible when there is a win-win situation for most of the value chain agents, including women and men producers. The Figure on page 24 describes the various inputs and services that cattle keepers can access through their POs.

The approach has been successfully promoted by a range of development partners, in both crop (e.g. coffee by TechnoServe) and dairy. Focusing on the dairy value chain, the approach has been followed in three countries of East Africa (Kenya, Uganda and Rwanda) during the first phase of the East Africa Dairy Development (EADD) project. Increasing poor livestock keepers' access to markets though the hub approach has had a positive impact on productivity and income. Indeed, active suppliers of producers organisations supported by EADD have seen an increase in milk productivity in their cross bred animals of between 50 and 60 per cent depending on the countries, with the largest increase recorded in Kenya. In Uganda, we also observe an increase in milk yields among local cattle. Even though difference in methodology between baseline and final evaluation prevents clear comparison, overall, there has been an increase in dairy income in nominal terms for the three countries and in real terms for Uganda (between 30 % and 130 %). For cattle keepers to have long-term access to markets, beyond a project support, the team developed a tool that assesses the PO's progress towards sustainability using both production and business dimensions, for example its ability to run Board elections regularly and freely or PO members' ability to access feed inputs on credit. A Producers Organisation 'graduates' when it reaches a certain score (60 %), meaning that external support, from development partners, is no longer required. Data have shown that on average, it takes 7.3 years for a PO to reach 'graduation'. Sites in Kenya and Rwanda have progressed significantly faster than Ugandan sites, while pre-existing sites have done so much faster than all the other hub types.

In other settings, productivity levels are low, and the research question is therefore whether the hub approach would be applicable in areas with little marketable surplus, with the first intervention point being increasing access to inputs and services to improve productivity. The approach is being tested in the pre-commercial areas of

Tanzania as well as in other livestock value chains, including the pig and small ruminants value chains.

Contract farming. In many cases, contract farming is seen as a useful way for smallholders to get access to both inputs and output markets in South-east Asia, but looking at evidence, the history of contract farming for livestock is mixed, and is characterised by various institutional arrangements, based on local conditions. In the case of pigs and pig meat value chain in northern Vietnam, Lapar et al. (2009) show that there are various possibilities for pig producers to access markets: they can engage in formal contracts with integrator companies or in informal contractual arrangements with co-operatives or with traders of inputs or/and of outputs. Smallholders usually find it difficult to enter into formal contract arrangements because of barriers due to scale: integrators offering formal contracts require relatively large-scale operations for efficiency purposes and to reduce monitoring costs (it is easier to monitor and supervise a few large farms than numerous small farms). Smallholder farms therefore need to find other mechanisms to access markets.

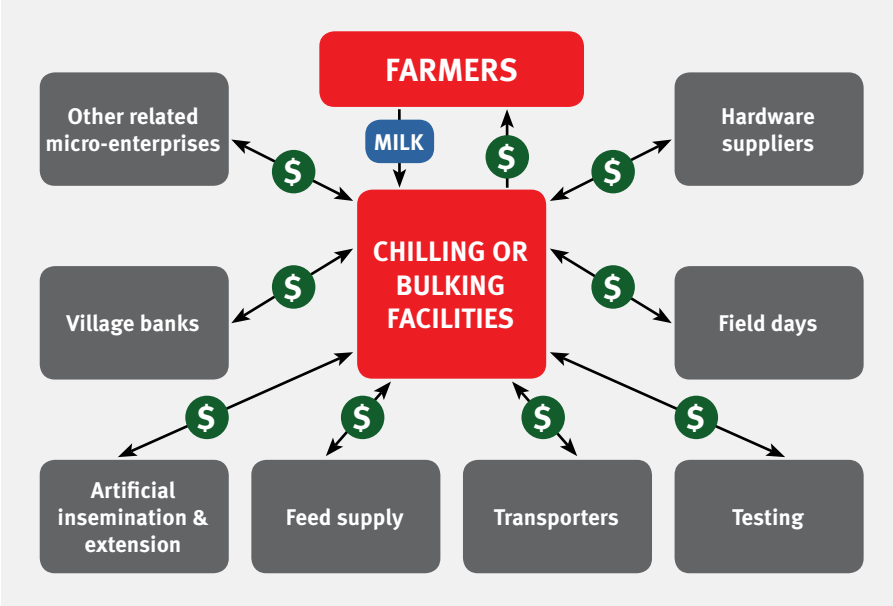
For the same reasons as integrators, traders also prefer larger-scale producers. It would therefore be important to examine the potential of co-operatives to facilitate profitable pig production by smallholders, as well as looking at the broader issue of product certification and infrastructure that smallholders can access and have the quality of their pigs assessed and certified (particularly for disease-free status or lean meat content) by according to specific grading standards. A partnership between large farms/companies and smallholder pig producers can also be envisaged, for an inclusive value chain approach.

Export markets – the case of Namibia and Botswana. The cases of the beef sectors of Namibia and Botswana are examples of livestock keepers succeeding in accessing high-end retail European markets. Both countries belong to the African Caribbean and Pacific Group of States, and like its other members, they have had historical preferential trading relations with the European Union under the Lomé-Cotonou agreement, now being reformed into the Economic Partnership Agreement (EPA). Namibia is among the top ten beef exporters to the EU, and it managed to penetrate the high-end niche markets in Europe. By shifting from marketing beef as a commodity to a smart branding and marketing strategy of selling their key beef attributes (e.g. free-range, hormone free, animal welfare), Namibian beef exporters have realised higher returns in revenue and in turn offer higher prices to producers. Key to this success has been the implementation of a credible individual cattle identification traceability system. Botswana, on the other hand, has been an inconsistent supplier due to export bans related to a weak traceability system and frequent outbreaks of foot-and-mouth disease (FMD). While in both cases, smallholder livestock farmers are able to supply this high-value channel, the extent of their participation is lower due to the high costs of compliance, frequent changes in EU standards, FMD control challenges, and the lack of land titles to secure bank loans that can enable them to add value to their livestock. As such, a mixed approach of market segmentation that strategically targets high-end international markets while also capturing regional market opportunities is more sensible. This can lead to a more inclusive livestock development.

The way forward

There is no 'one-size-fits-all' approach to link livestock keepers to the market in a manner that is inclusive and sustainable. Women's and men's needs have to be taken into account for a value chain transformation to happen. There are still many unknowns, in particular regarding the effect of increased market orientation on the household nutritional status. In fact, the effect can be negative when more livestock products (like milk) are sold rather than consumed at home, extra income is spent on items not beneficial to children health and nutrition, and women's workload increases and less time is available to care for their children. Concerted efforts by researchers, development partners, public and the private sector are needed for inclusive value chains to become a reality so that poor livestock keepers can take advantage of the Livestock Revolution to improve their livelihoods in a sustainable manner.

The EADD hub approach



Milk production pays off! – Experiences of a DPPP approach in Northern Sri Lanka

The Northern Province of Sri Lanka is a post-conflict area with large numbers of repatriates. Many of them were involved in agriculture and animal husbandry before the war, while others are newcomers. The majority of dairy livestock in the Jaffna district are reared in small-scale operations, with 46 per cent of the farming families owning fewer than five cattle and less than five per cent owning more than 16 cattle. Many cattle are Jersey crosses, but the production level is rather low. The government of Sri Lanka seeks a substantial increase in national milk production and at least 50 per cent self-sufficiency by 2015. The dairy industry has considerable potential to contribute to economic development. There is a promising regional market for milk. Since safe cool chains are lacking, up to 80 per cent of the milk produced in the North is transported to the South, and a large amount is converted into milk powder. With easy storage requirements and long shelf life, UHT milk could be an adequate option in future.

Much could be improved on the production side. Animals are kept in a semi-intensive management systems, milked only in the morning, and fed mostly based on paddy straw plus rice residues. Commercial feeds and crop residues available in market are rarely fed, and there is little coverage of artificial insemination (AI) services. The result is low milk yield and short lactation periods. In addition, there is a shortage of quality animals that are able to produce higher yield for those who want to expand. Many farmers, in particular the newcomers, lack knowledge in dairy production. Their access to financial services is limited. Not all farmers sell their milk through the formal channels. Much of it is sold in small quantities on the informal market and to schools under unhygienic conditions.

Initiated by an international packaging company and a local retailer enterprise a project was set up in 2013 supported by the GIZ "development partnerships with the private sector" (develoPPP) initiative. The project aims at an increased quality and quantity of milk production and medium-term coverage of the regional demand. A transfer from small-scale semi-intensive dairy farmer to market-oriented producer is needed to improve income and food security. The project focuses specially on involving women and creating jobs for young people along the dairy value chain. It is jointly carried out by all three partners.

The following three pillars are crucial to its success:

Setting up a dairy hub – an approach that has been successfully introduced by an international packaging company to Bangladesh, Pakistan and India. This is a one-herd concept that encompasses smallholder farmers from 50 to 60 villages located within a 20 to 25 kilometre radius. Dairy hubs shorten the supply chain and make milk collection more efficient. A milk collection centre was established in late 2013 and small collection points have been set up. The milk collection centre is managed and owned by a local dairy processor. Many collection points are managed by local women. All milk is tested upon arrival. Registered farmers can supply their morning and evening milk without any quantity limitation. They receive a fair price based on the delivered quality which is slightly above the set average milk price. A steady supply of milk is needed to establish a credible marketing system. The supply system needs to be constantly monitored. Improved usage of available by-products is promoted, and opportunities to provide the farmers with high quality feeds (ingredients) at a reasonable price are investigated. Supply of commercially available feed is supported, and small-scale trade with feed and fodder

Photo: C. von Morstein

Female participation in dairy production needs further attention.

is encouraged. The promotion of production and use of improved fodder plants has started, and storage and conservation methods will follow soon. AI services are to improve through the project's own AI techniques.

Constant training and advisory services are needed to improve the production and help the farmers become an agripreneur. A team of female and male extension workers have been trained in dairy production and are receiving coaching. They pay regular visits to individual farmers and farmers' groups. Appropriate training and extension material is under preparation under the consideration of gender-sensitive extension approaches.

The establishment of rural milk producer groups is essential for the sustainability of the project activities. Therefore, the formation of producer groups has been supported to increase farmers' voice and visibility and strengthen the position of female famers. Extension services are provided to members free of charge or at a reasonable cost. Registered producer groups will have better access to financing instruments and credits and options to set up their own small rural milk collection points.

Already eight months after the opening of the collection centre, the monthly collected amount of milk has increased from 3,100 litres to 35,610 litres, and the number of participating farmers has increased tenfold. Greater awareness of hygiene and milk quality is developing, and milk quality has improved, too. Participating farmers earn around 20 per cent from regular milk supply. They have already started to invest in their dairy business. Higher income is expected after the next calving under an improved management and feeding regime. Dairy farming is becoming the primary business of more and more farmers, and motivation to invest in dairy is growing. Female participation needs further attention, although some women excel at managing collection points.

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Food security and poverty mitigation through smallholder dairy – the Zambian case

Supporting smallholder farmers is one of the best ways to fight poverty and ensure food security. Such support involving the active participation of smallholder farmers in Zambia has demonstrated a significant increase in farmers' engagement in general and an improvement in milk production, resulting in nutritional food security both at household and national level and income for the poor farmers.

Making smallholder dairy production more competitive is becoming a powerful tool for reducing poverty, raising nutrition levels and improving the livelihoods of a large number of rural poor people. The dairy is an activity 365 days a year, unlike crop farming, where farmers depend on rain-fed agriculture. This presents a unique opportunity to establish sustainable dairy chains that can meet the demands of local consumers and of the regional market, as can be seen in the following example.

A favourable context

Zambia's estimated three million cattle (dairy and beef) are owned by three categories of farmers. Traditional cattle keepers own about 80 per cent of cattle and their livestock products rarely enter the commercial chain, unless for compelling reasons. The second group is commercial farmers, who own less than six per cent of the cattle and are market-oriented with improved animal husbandry practices. The third category of farmers is smallholder (dairy/beef) farmers who have a market-oriented approach to livestock keeping and own about 14 per cent of the cattle. In Zambia, there are currently an estimated 300,000 traditional cattle farmers, 90 commercial dairy farmers and 4,000 smallholder dairy farmers. Most commercial dairy farmers and smallholder dairy farmers are located in Southern, Central, Lusaka and Copperbelt Provinces, while traditional cattle farmers are located in Southern, Central, Eastern and Western Provinces.

Zambian smallholder dairy farmers achieve relatively high incomes per litre of milk. They are also comparatively resilient to rising feed prices as they usually only use a small quantity of purchased feed during the dry period of the year. Moreover, there is a growing demand among consumers in the region and the country as a whole for milk and dairy products, driven by population growth and rising incomes. However, smallholder dairy production will only be able to reach its full potential if some of the challenges the sector is currently facing are addressed. Smallholder farmers lack the skills to manage their farms as 'enterprises'. They have poor access to support services like production and marketing advice, and they have little or no capital to reinvest and only limited or no access to credit. Moreover, they are handicapped by having no dairy breed or genetic improvement programme, resulting in a low milk yield potential.

Interventions and impacts

Over the last few years, a wide range of activities have been launched to address these challenges. One example is the initiative by the Golden Valley Agricultural Research Trust (GART), a public-private partnership founded in 1993. In collaboration with several stakeholders, among them the Zambian Government, Land O' Lakes, Common Fund For Commodities, Heifer International, European aid agencies, and milk processors such as Parmalat, Creamwell and Zammilk, various

Photo: G. S. Pandey

Production and supply of milk by small-scale dairy farmers is creating a large number of jobs for youths, thus enhancing rural development and preventing rural-urban migration.

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measures were carried out along the entire value chain, including training, exchange visits, improving market access and improved feeding, pasture and fodder conservation. Here, both local and dairy cross breed cattle were used – with a view to dairy genetics improvement through artificial insemination and restocking taking place in the future.

As a result, a dramatic change has been seen in smallholder dairy development, resulting in increased milk volume delivery through improved productivity of milk per cow from 2 litres per day in 2004 to 5 litres per day in 2014, joining more farmers in milk marketing and improved hygienic and compositional quality of milk attracting better price and acceptability of quality milk by processors. This has enabled better marketing and better income for the farmers. Above all, the establishment of a number of milk bulking points in traditional cattle-keeping rural areas and linking them with processors as well as timely, good and guaranteed payment by the processors has led to considerable improvements in the life of poor smallholders through regular and enhanced income. In the last five years, for example, many new full-time jobs have been created in dairy and dairy-related business, the current number being about 5,000 people. Around 15 youths get employed directly and indirectly after every 100 litres of milk produced and marketed, indicating that dairy is a good employment opportunity in the rural setup of Zambia. Another promising development is that a number of women farmers and female-headed households work fulltime in smallholder dairy business and perform better than their male counterparts. Women are the most likely agents of change, and when women and girls earn income, they reinvest 80–90 per cent of it in their families, compared with only 30–40 per cent for men.

Promoting the establishment of farmers' organisations like dairy co-operatives at village level and the farmer's body 'Dairy Association of Zambia' at national level was a further important step. These organisations provide small-scale producers access to services like markets for milk including bargaining and negotiating power. In 2001, Zambia had only three functional dairy co-operatives that were receiving about 500 litres of milk per day. By the middle of 2014, there were 52 active dairy co-operatives, owned and managed by 7,800 smallholder dairy and traditional cattle farmers receiving more than 80,000 litres of milk per day. The share of smallholder dairy production in total liquid milk going into dairy processing industry in Zambia was raised from 5 per cent in 2005 to 30 per cent in 2014. The main dairy products processed in Zambia by four big dairy processors and another 14 small-scale dairy processors include fresh pasteurised milk, UHT, fermented milk, butter, cheese, cream, ice-cream and milk-based juices and sweets. Nearly all the products are consumed within the country, with a little export to the Democratic Republic of Congo by Parmalat, although opportunities exist for export in the region once more volume of milk is available to processors to run their full capacity.

A great potential

The total annual production of milk in the country is estimated to be about 300 million litres, with 25 per cent supplied by commercial farmers, 13 per cent by smallholder farmers and 62 per cent by traditional cattle keepers. Of this, only 95 million litres is processed, and the rest remains in the informal market and for home consumption. An attempt was started in late 2013 and 2014 to commercialise the potential availability of milk from the untapped traditional cattle keepers to mop the milk into the formal market by establishing 16 milk bulking points in Southern, Lusaka and Central Provinces. It is estimated that the traditional sector alone from 15 districts of Zambia having major cattle populations in Southern, Central and Western Provinces could contribute up to about 57.5 million litres of milk per year to the formal market if market development and infrastructure were to take place in the above traditional cattle-rearing areas and they were linked with processors. Recently, the measure has been complemented through a 'loan a cow' scheme by the Zambia National Commercial Bank and Dairy Association of Zambia, who have imported more than 400 dairy incalf heifers this year, and most of them are located in the milk belt area of Southern, Central and Lusaka Provinces. Farmers have already started delivering milk to dairy co-operatives, contributing to increased volume of milk in 2014.

In 2005, about 483 active smallholder dairy farmers from Southern, Central and Lusaka provinces delivered 1.4 million litres of milk, receiving 370,000 US dollars (USD), while in 2013, a total of 1,219 active farmers delivered 5.5 million litres, worth 2.7 million USD. By the end of 2014, given more traditional cattle farmers who have already joined dairy and a new processor having established a dairy plant and the establishment of new milk bulking points, about 1,985 active farmers could have delivered 9.4 million litres, receiving 5.5 million USD in the Southern, Lusaka and Central Provinces alone.

Conclusion

The contribution of the livestock sector to nutritional food security, poverty alleviation and sustainable economic growth can be further improved with renewed commitments from major stakeholders and a review of pro-poor farmer policy, especially regarding market access, trade, dairy breeding stock availability and their improvement, as well as soft loans with little or no collateral. If this is further strengthened, a huge potential could open up in Zambia for attracting new markets and trade partners, the inflow of private investment for new production technology and food for niche markets. The author firmly believes that even for other countries with scenarios similar to that seen in Zambia, intervention in smallholder dairy is an assured path of sustainable development in the area of nutritional food security, job creation for youths and poverty reduction, resulting in enhanced rural development.

Animal husbandry in cities – using potentials, reducing risks

Not only rabbits and guinea-pigs but sheep, goats, cattle and pigs also play a crucial role in the food and income situation of countless city-dwellers world-wide. However, when people and animals live in such close proximity, health risks are inevitable. But instead of banning urban animal husbandry, as was, for example, considered in the course of the swine influenza epidemic, framework conditions ought to be created that enable people to make use of this business branch to earn a profit without running risks.

Different forms of keeping animals in cities for agricultural purposes have existed for a long time. In the Maya Empire and in China, but also in Europe, animals were already kept in cities in biblical times and during the Middle Ages. Horses and camels served as a means of transport for goods and armies, of which street names are still a reminder in many places. Just 100 years ago, cows in Copenhagen were fed with scraps from beer production, while Londoners kept rabbits on their balconies during the Second World War.

Today, animal husbandry still plays a frequently underrated role in small cities and urban centres, especially in developing countries and emerging economies. The animals are kept seemingly invisibly, predominantly in the disadvantaged city areas. For the poor population, these farm animals are often an important contribution to food security, whereas more wealthy strata of the population above all keep animals as a status symbol and as pets. While frequently ignored by the authorities, neither potentials that urban animal husbandry entails nor the risks it bears are considered in planning and support processes for the local population.

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Photo: J. Boethling

Stable with buffalos for milk production in suburban Andheri, India.

In the cities, a very large share of the population live in absolute poverty; many of them have migrated from the rural areas. The poor urban population spend most of their income on food, and only little surplus remains (see also Figure on page 30). Just a small share of food costs is spent on animal products, although the (quantitative) demand for milk, eggs and poultry is high. This raises the risk of catching diseases caused by food of uncertain origin.

Many migrants from rural areas have brought their farm animals into the cities as living inventory, and sometimes even as their only possession. The animals represent an important link to their home locations. Frequently, the animals land in the slums, together with their migrant owners. But a lot of old-age pensioners and civil servants also keep animals in the cities, and the lower middle classes have discovered urban animal husbandry as an interesting investment option. Since many women stay close to their households during the day, they usually look after the animals as well. The women are often responsible for the processing and marketing of the products. The sale of milk and eggs secures a small daily income for them, which is frequently vital for survival.

Urban animal production as an (economic) factor

Figures on how many animals are kept in cities and how high their contribution is to food and income security are not available. Animal production takes place mainly at subsistence level and in the informal sector, so

Example of the contribution that urban milk production makes to the food and income situation of urban households in a Nairobi urban district

Income
- 68 per cent of households are fully dependent on animal husbandry.
- Monthly net income per households: 60 US dollars (USD) per dairy cow.

Food
- Average family milk consumption: 2 litres per day.
- Children consume 53 per cent of the milk.
- 71 per cent of milk income is spent on buying food.

Job creation
- 71 per cent of households employ wage labourers.
- 82 per cent of the household members work in the milk sector.

Access to credit
- 27 per cent of households have access to credits of more than 700 USD.
- The households take part in informal rotating credit systems (Rotating Savings and Credit Association – ROSCA).

Financial security – "bank on hoof"
- 50 per cent of food is financed by income from dairy livestock husbandry.
- 42 per cent of health expenditure is raised by dairy livestock keeping.
- 72 per cent of school fees is financed by income earned by keeping dairy livestock.

The re-investment rate is at 58 per cent.

that the economic contribution is not known in detail. Various studies nevertheless give an impression of its significance. For example, there are reports that in Bamako/Mali, farm animals are kept in more than 20,000 households and thousands of people are responsible for looking after them. A survey in Harare/Zimbabwe shows that more than a third of the households keep chickens, hares, pigs, ducks or turkeys. In Dar es Salaam/Tanzania, urban animal husbandry is the second most important branch of the economy after petty trade and the services sector, and 74 per cent of the urban population have farm animals. In Asia (e.g. Hong Kong, Singapore, Calcutta or Dhaka), keeping pigs and chickens and fish-farming is very widespread. Out of 546 households interviewed in four districts of Hue (Vietnam), around 30 per cent keep farm animals, and even 80 per cent do so in Dhaka/Bangladesh. In poor districts of Lima, La Paz or Mexico City, pigs, chickens and guinea pigs are kept in backyards and on rooftops. Experience among cattle-breeders in India shows that up to 80 per cent of them are without land, while the majority of them are women. Each of them has between one and three cattle, and dairy contributes to up to 45 per cent of families' gross income, securing their survival. The significance of animal husbandry is highly diversified, as a concrete example from Kenya shows (see Box above).

In many cities around the world, keeping farm animals is closely linked to gastronomy. Small restaurants are regularly supplied with local produce, and the short routes involved and the fresh products are highly appreciated. However, there are also examples of value chains in urban animal husbandry on a very large scale, as the example from Cairo shows (see Box below).

Pig production in Cairo


Photo: C. von Morstein

In the multi-million city of Cairo, the Coptic Zabalin (dustmen) have traditionally kept pigs for centuries. In highly aggregated value chains based on a division of labour, they kept around 350,000 animals for breeding and fattening, and the animals were slaughtered and sold. About 70,000 people were involved in this value chain, and enormous turnovers were generated. The animals were fed mainly on organic waste gathered by the Zabalin. In the course of the outbreak of so-called swine fever in 2009, all the animals were slaughtered. Not only did this spark great protest, but it also led to enormous rubbish and hygiene problems throughout the city. The action taken was subsequently declared a general health measure.

Production systems and their risks

Since the urban dwellers often own little or no land, the animals can be found wherever there is room for them: in backyards of buildings, on balconies and rooftops, on (municipal) wasteland, in the streets and alleys, but also on rubbish tips. The cramped conditions that the livestock are kept in and the lack of infrastructure cause stress, loss of production but also injuries among the animals, which results in lower production. They are fed on both organic waste from the households and on all food that animals roaming freely tend to find. They graze on wasteland and other green spaces. But waste/residues from industrial production (beer brewing, grain processing, etc.) get to the cities and are sold there by merchants. There is also a flourishing trade in concentrated feed and green feed from the surrounding areas.

All sorts of animals can be found throughout the cities of the world. There are a wide range of production systems and regional varieties, as the Table on page 30 shows. However, living together closely with the animals results in hygiene and health problems. Often, excrements and urine are not removed in time, properly disposed of or exploited as natural dung.

Classification of animal husbandry systems in cities *(Source: taken from Reiber, 2012)*

Type of animal	Sheep + goats (meat)	Pigs	Poultry, pigs, rabbits, guinea pigs, etc.		Dairy livestock (goats, sheep, buffalos, cattle)	
	West Africa	Asia, South America	Tanzania, Egypt, Andean countries		India, Egypt	
Chief products	Meat, dung	Meat	Meat, dung		Meat, dung, milk	
Capital input	Low to high	Low to high	Low	Low	Low	Low
Breeding (use of exotic races)	-/(x)	-/(x)	-	x	-	x
Feeding • by-products • concentrated feed • rough fodder	 x (x) (x)	 x (x) (-)	 x - (-)	 - x (x)	 x (x) (x)	 - x (x)
Accommodation in stables	x	x	-	-	x	-
Main purpose	Subsistence/ commercial	Subsistence/ commercial	Subsistence	Commercial	Semi-commercial	Commercial
Size of stock	Small to medium	Small	Very small	Small	Small	Small
External inputs	(x)	(-)	-	x	-	x
Land ownership	+/- Tolerated on municipal land	Tolerated on municipal land	No land		Informal	Leasehold
Animal owners	Rich and poor	Poorer	Poor	Richer	Poor	Poor

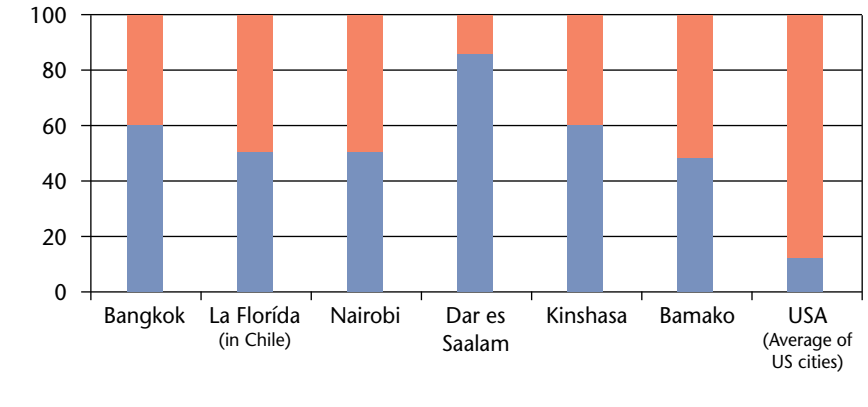
Proximity to the animals encourages the spread of zoonotic disease such as bird flu or tuberculosis, but also vermination. Older people, women and children are particularly at risk because they spend more time with the animals. The partly uncontrolled intake of food by the animals can also lead to contaminated food or indigestible material being eaten. Thus toxic substances very quickly enter the food chain via products such as milk and eggs.

Opportunities thanks to improved and safe urban animal production

There is international agreement that the banning of urban livestock husbandry is neither socially nor politically acceptable and therefore no solution. This is why the creation of more suitable framework conditions and the support of solution strategies is recommended. This starts with the greater appreciation of the contribution made by urban animal production by government, municipal and non-governmental institutions (NGOs). The beneficial role of urban livestock husbandry also ought to be considered in municipal planning e.g. in the allocation of urban wasteland and clear regulations. With the provision of the necessary infrastructure, such as veterinarian-controlled slaughterhouses and disposal of dead animals and slaughterhouse waste, health risks can be reduced considerably, and the quality and value of animal products can be enhanced. Necessary measures such as deworming and vaccinations could be promoted by municipal and private animal healthcare. What is of considerable importance is for women to take advantage of services such as consulting on food and hygiene issues as well as on health topics like zoonotic diseases. Furthermore, gender-sensitive capacity building among keepers of livestock and consultants could enhance animal performance, improve the quality of animal products, develop the value chains and, ultimately, raise income. Through the improved management of excrements and other waste from animal production and their exploitation as organic fertiliser, environmental pollution could be significantly reduced.

Promoting producer organisations could enhance the position of – female and male – members vis-à-vis the authorities and in the procurement of feed and services as well as in joint marketing.

Share of urban household expenditure on food



Source: Akinbamijo et al., 2002

What is needed for reducing the greenhouse gas footprint?

Livestock production is responsible for a large amount of greenhouse gas (GHG) emissions. However, numerous approaches have been developed to reduce these emissions and thus lower environmental pollution caused by livestock husbandry. This article shows where interventions are possible and which hurdles have to be cleared in implementing the various measures needed.

Increasing consumption of livestock products due to changes in people's diet and greater food demand of a growing world population has been highlighted by the scientific community and public media as a major threat to the global climate system as well as other aspects of the global environment, specifically land degradation, water pollution and biodiversity loss (FAO, 2006). Increasing greenhouse gas (GHG) concentrations in the atmosphere (particularly carbon dioxide – CO_2, methane – CH_4 and nitrous oxide – N_2O) are driving global climate change (IPCC, 2013). Enteric fermentation during feed digestion by ruminants is a major source of atmospheric CH_4 (see Figure on page 33). Moreover, CH_4 and N_2O are released following excretion of faeces and urine e.g. on pastures, as well as during storage and application to agriculture land. In total, it is estimated that livestock-related GHG emissions, defined as the "sum of emissions from enteric fermentation and manure emissions, plus emissions from cropland for feed cultivation", represent over 80 per cent of total agriculture emissions or 12 per cent of total global anthropogenic emissions (Tubielle et al., 2013).

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Regional discrepancies

Dairy and beef cattle in the more developed regions (Europe incl. Russia, Oceania and North America) comprise approximately 18 per cent of the global cattle stocks; thus about the same number of cattle that can be found under totally different production and climatic conditions in sub-Saharan Africa (SSA). Production conditions differ largely across these regions and climate zones (Herrero et al., 2013), and with them the livestock management practices and the availability and nutritional quality of feedstocks. These differences result in markedly different GHG emissions from ruminant livestock. For example, while emissions per kg of edible milk protein range from 10 to 20 kg CO_2 equivalents in Europe or North America, respective emissions in SSA are in excess of 100 kg CO_2 equivalents per kg edible milk protein, approximately one order of magnitude higher. Major reasons for this discrepancy in the GHG emission intensity between more developed and developing regions are generally related to differences in feed intake, diet composition and nutritional quality of feeds, as well as animal species and breeds (i.e. genetic potential, adaptive capacity, etc.), although differences in reproductive rates, health and mortality and overall herd and farm management may also contribute. Besides, handling of animal wastes and its use for crop and feed production may be less sophisticated in developing than in developed regions, resulting in higher nutrient losses and GHG emissions.

Diet additives – pros and cons

Hundreds of peer-reviewed publications on feeding strategies to mitigate CH_4 emissions from enteric fermentation in ruminant production have been published during the last decades, including several extensive review papers (Hristov et al., 2013). Diet additives such as plant secondary compounds (e.g. tannins, ethereal oils), electron receptors (e.g. fumarate), ionophores (e.g. monensin) or dietary lipids with high proportions of unsaturated fatty acids were frequently shown to reduce enteric CH_4 production. However, effects, if expressed in CH_4 per unit of digestible feed intake, are relatively small, and doubts exist whether they persist in the long term and are transferable to on farm and different production situations (Knapp et al., 2014). Moreover, these additives are partly toxic or prohibited in animal feeding and are likely to be unavailable or too costly for (smallholder) farmers, particularly in rural regions of the world. Methane production during enteric fermentation is essential to reduce hydrogen load in the rumen and thereby maintain its functioning. Above-mentioned rumen

Greenhouse gas emissions from ruminant livestock vary considerably depending on production conditions. In sub-Saharan Africa, for example, levels of emissions per kg of edible milk protein are several times higher than in Europe or North America.

Photo: J. Boethling

modifiers therefore may interfere with feed digestion and thus hamper animal health and performance (Knapp et al., 2014). Hence, any strategies to increase feed use efficiency (i.e. product yield per unit of feed intake) in ruminant production, such as tactical supplementation of high-quality feeds or the processing of forages to improve their digestibility, are considered the most effective and promising mitigation measures to reduce methane emission intensity.

Optimising N-use efficiency

In terms of N (nitrogen) emissions, efficiency of N use by ruminants is very low. Even in high-yielding dairy cows, only about 25 per cent of the ingested N is converted into milk protein. Efficiency values range from 15 to 40 per cent (Calsamiglia et al., 2010), showing that there is a great potential to reduce N_2O emission intensity through feeding and management optimisation compared to CH_4 without impairing gastrointestinal tract health and functioning. For instance, adjusting N intake to actual requirements of rumen microbes and the host animal, while taking into account rumen microbial protein synthesis and N recycling via the ruminohepatic cycle, can considerably reduce N losses from ruminant systems (Dijkstra et al., 2013). Besides, feeding and feed management strategies, such as feed processing technologies, the use of secondary plant compounds to protect feed protein from microbial degradation or the synchronisation of N and energy supply to rumen microbes, may greatly increase duodenal protein flow and reduce ruminal ammonia absorption and, consequently, N excretion via urine. These measures will thereby enhance N use efficiency at individual animal level while modifying excreta composition and reducing N emissions from animal manures.

A holistic approach is needed

Reducing the GHG footprint requires an examination of the entire livestock production system; from feed cultivation to the animals themselves (see above) and to management of the excreta. This will require a holistic approach to reduce losses from the system. For example, monogastric species are sometimes promoted as a climate mitigation strategy because they are more efficient and produce less GHG emissions than ruminants. However, the additional environmental costs associated with the higher quality feeds required by monogastrics and the direct competition with humans for edible plant biomass should also be accounted for (Gill et al., 2010).

For feed production, much of the GHG emissions is related to N fertiliser applications to the soils. However, effective fertiliser management (i.e. altering the type of fertiliser, timing of application, matching applications to crop requirements, etc.) can reduce these emissions. This may also entail re-using livestock waste where applicable, although care must be taken since in some soils (particularly those with low C content) adding manure as a fertiliser may increase soil N_2O emissions relative to synthetic N fertiliser applications (Velthof et al., 2003).

Sound manure management

With the exception of grazing systems where the animals excrete directly onto the pasture, livestock production generally requires some form of manure management (e.g. storage and removal/application to land), which provides further risk of nutrient loss and GHG emissions. Simple storage methods such as compacting and covering solid excreta can reduce N_2O emissions by up to 90 per cent as well as NH_3 emissions (that can then cause offsite GHG emissions) by up to 30 per cent (Chadwick, 2005), while reducing the surface area:volume ratio of the slurry storage pits or capping the pits will also reduce emissions. Further, manure can be used as an energy source through its use in biogas plants and the controlled conversion to CH_4, although care must be taken to ensure that no leakages occur as this may even increase total GHG emissions (Bruun et al., 2014). Finally, the manure (or slurry from the biogas plant) can be used as fertiliser, reducing the need for external inputs (e.g. synthetic fertilisers that require energy during production) while potentially lowering leaching and gaseous losses compared to mineral fertilisers. However, prior treatment (e.g. digestion, filtration etc.) and an appropriate application method (injection or incorporation or trailing hose) should be used to reduce gaseous N losses, al-

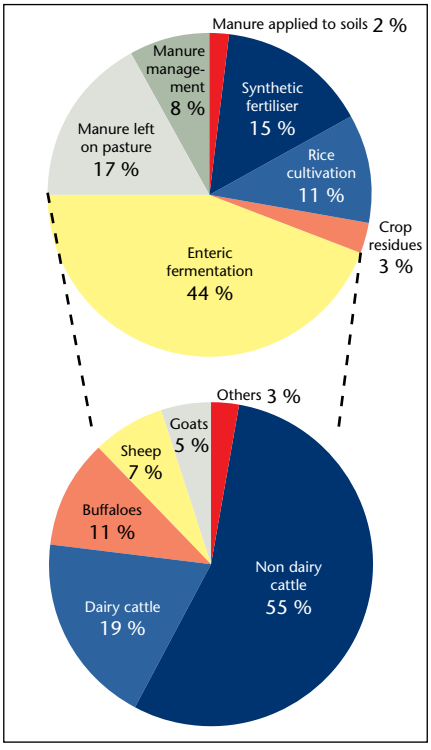
though technologies that reduce NH_3 emissions often increase N_2O emissions and vice versa (Petersen et al., 2011).

Research needs: focusing on the South

Generally, research on the environmental impact of livestock production systems has been focused nearly exclusively on production systems in developed countries. However, more than three quarters of global livestock is kept in so-called developing countries, making it obvious that significant mitigation of GHG emissions from livestock systems requires much more knowledge about such systems as the basis for the development of region-specific mitigation strategies.

- Reducing GHG emissions from livestock in developing regions will require a sustainable intensification of current livestock systems. For this, complementary feeding, and herd and manure management schemes that enhance animal productivity while minimising environmental impacts from livestock for a broad range of diverse production conditions need to be investigated.
- In view of the diversity of feeding situations world-wide, much research is still needed on feed protein evaluation and the efficiency of microbial protein synthesis to be able to minimise dietary protein supply without compromising animal performance.
- Livestock production systems are often detached from crop production systems in terms of nutrient cycling and recovery. Regional scale options to better link livestock and crop production need to be explored, which would not only benefit the productivity of overall systems but also tighten nutrient cycles and thereby reduce GHG emissions.
- Adoptability of such feeding or management strategies for crop and livestock producers must be explored for different production systems. Also, system analyses that consider interactions of different strategies at larger temporal and regional scales are needed. These analyses should consider all functions and deliverables of livestock within farming systems and not just the amount of edible products produced (e.g. draught power, financial security, etc.), which for smallholder farms, may be of similar or even higher importance than crop, meat or milk yields themselves.
- Due to a lack of measurement and information, the magnitude and spatial distribution of livestock GHG emissions are highly uncertain. In SSA for example, no in situ data on ruminant CH_4 emissions are available, nor is there any information summarising feeding practices, seasonal changes in nutritional quality and availability of feeds for most of the livestock systems. Lack of information hampers developing countries in including livestock systems in emission-trading schemes or in improving their national GHG inventories by using country-specific emission factors (e.g. Tier II instead of Tier I method of the International Panel on Climate Change).

Percentage contribution of different agriculture categories to total greenhouse gas emissions from agriculture (2010: 4,586 Mt CO_2 equivalents yr^{-1}), breakdown of the global enteric emission estimate by animal type (average for 2000-2010)



Concluding remarks

Livestock production systems are responsible for a large amount of anthropogenic GHG emissions. However, there is also an opportunity for large emission reductions through improved (system-specific) feeding and manure management, primarily in low-yielding smallholder production systems of many developing countries. Accurate quantification of the reductions in GHG emissions (or emission intensities) and the development of sustainable intensification strategies require empirical data on existing (in particular smallholder) systems using a holistic, multidisciplinary systems approach.

References and sources for further reading: ➤ **www.rural21.com**

Selected determinants and mitigation strategies for reduced emission intensities from ruminant production

Enteric fermentation

Choice of diet ingredients
Improved diet digestibility
Enhanced feed intake capacity
Feeding management
Rumen modifiers

Herd management & performance level

Choice of animal species/breed
Genetic selection
Herd structures
Health & fertility management

Feed production & storage

Choice of feed types/origin
Plant breeding
Improved harvest methods
Optimised fertiliser use
Feed conservation/processing technologies
Feed waste management

Manure storage & use

Adapted protein intake
Reduced protein degradability
Improved diet digestibility
Use of fibrous feeds
Optimised excreta management
Excreta recycling

The insatiable hunger for cheap meat

If the current trend in global meat demand persists, meat production will need to rise from 300 million tons today to 470 million tons by 2050. Climate and our natural resources would lose out, our author warns.

There is a growing global demand for meat. The trends in different regions of the world, however, differ substantially. In Europe and the USA, traditionally the largest meat consumers in the 20th century, meat consumption has been stagnating or even declining. A number of people, albeit small as yet, is eating less meat or no meat at all. Especially in urban areas there has been something of a shift towards healthy low-meat diets. People want to know where their food comes from and how it has been produced. One of the reasons for this trend is the long list of meat scandals, ranging from rotten meat in the food chain and dioxins in chicken feed to horsemeat being sold as beef.

In contrast, demand for meat is growing rapidly in the five major emerging economies of Brazil, Russia, India, China and South Africa, known by their acronym BRICS. In the BRICS countries, which combined represent 40 per cent of the world population, meat consumption rose by 6.3 per cent per year between 2003 and 2012, with a further 2.5 per cent increase per year being expected for the 2013-2022 period. This means that approximately 80 per cent of the world's meat sector growth by 2022 will occur in developing countries (see also Figure).

There are, however, major differences in consumption structures in the world's two most populous countries, China and India. In India, vegetarianism has deep cultural and social roots. Many Hindus do not eat any meat at all for religious reasons. In surveys, between one in four and one in three of all Indians declare themselves to be vegetarians. But the number of meat eaters is on the increase. Since the start of the economic boom in the early 1990s, a new burgeoning middle class has been changing their way of life to resemble that of their western counterparts, and this includes the consumption of meat. Nonetheless, Indian per-capita meat consumption is less than one tenth of the level now reached in China.

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There are also disparities in the new consumption structures within individual countries. Especially in the urban conglomerations meat consumption is on the rise. In China, animal-based protein consumption in the cities is increasing twice as fast as in the rural areas. City-dwellers tend to be more affluent than rural dwellers. They eat more food overall and their dietary habits differ from those of their rural counterparts, especially where it comes to animal-based foods. In 2011, Chinese rural dwellers consumed 26.1 kg meat, dairy and egg products – a 12.4 kg increase compared to 1990. During the same period, urban Chinese consumers increased their consumption of animal-based products by 19.1 kg to a total of 48.9 kg.

If this trend in global demand persists, the world's farmers and agribusiness enterprises will need to boost global meat production from 300 million tons today to 470 million tons by 2050, generating very serious ecological pressures and social impacts along the value chain. Production structures will change increasingly. While 50 per cent of all pigs in China today are raised on smallholdings, this pattern will soon change unless preventive action is taken. The same technology- and capital-intensive processes that dominate livestock production in the northern hemisphere are pushing into the lucrative southern markets, where livestock production in industrial-scale finishing units is rapidly gaining ground.

This is despite the fact that today's production environment could hardly be more different from the past. Industrial-style livestock production in Europe and the USA was established under conditions of low feed prices, low energy costs and cheap land resources. Nowadays, agricultural land, feed and energy are scarce and costs are high. This is why meat production levels are growing less strongly now than they did in the past few decades, with the exception of pig and poultry production. The latter two livestock categories have good feed-to-product ratios and can be kept at high densities, thus meeting the insatiable demand for cheap meat.

It is difficult to see right now how all this livestock is to be fed in the future, as such large quantities of meat are not produced in traditional systems where the animals graze by the side of the road or out on pasture. Theoretically humans and ruminant livestock do not compete for their food and

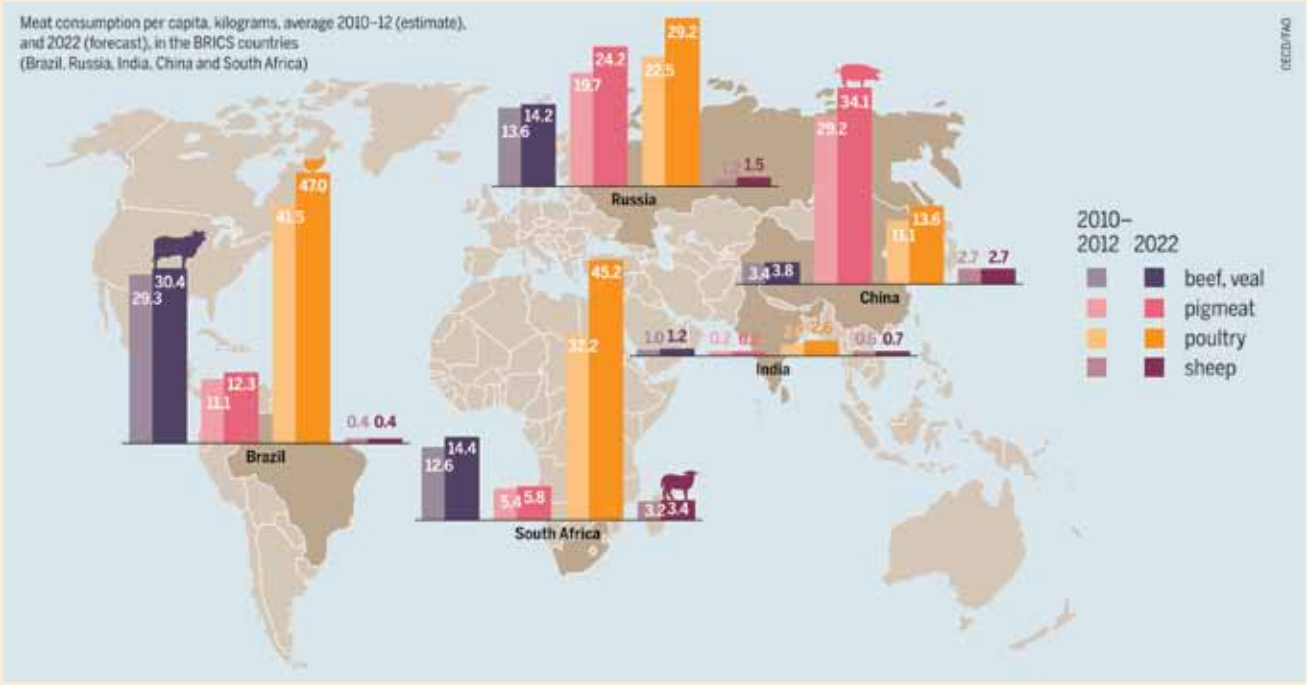
feed, with bread grains being grown in one plot and grass and clover for the cow in the other. But those kinds of systems are long outmoded. In order to get more production out of the animals than would be possible using relatively low-energy feeds such as grass, silage and hay, high proportions of protein-rich concentrate feeds are added to the animals' daily rations. Almost a third of the world's arable land is now devoted to producing feedstuff for livestock. Soya is and will continue to be the prime feed protein source and soya bean production alone will need to be doubled from its current global level of 260 million tons per year to 515 million tons. Per-hectare yields will need to increase or more land must be devoted to soya beans – or both.

The world's major soya bean producers are the USA, Argentina and Brazil, while China and the EU are the biggest importers. Three quarters of the soya produced worldwide ends up in China; the EU imports a total of approximately 35 million tons. The quantity of soya beans imported into the EU converted into virtual land comes to 17 million hectares of arable land, roughly the same as the entire agricultural area of Germany. Industrial-style livestock production therefore does not avoid land take. Quite the opposite is true: the production of feedstuff competes with food production on a large and environmentally damaging scale.

Feed production in particular is associated with massive greenhouse gas emissions. Climate-damaging emissions are not only generated in the form of methane resulting from ruminant digestion, but large quantities of nitrogen oxides, including nitrous oxide which is 300 times more damaging to our climate than carbon dioxide, are emitted as a consequence of land-use change as well as fertiliser and pesticide use associated with the production of livestock feed. And feed production is not only bad for our climate – industrial-style livestock farming also pushes other planetary boundaries through biodiversity loss, marine eutrophication and impacts on the global nitrogen cycle.

And yet it would be so easy to make changes at various different levels: The average German presently consumes roughly 60 kg of meat per year. This means that meat is consumed daily and with almost every meal. Even just a reduction in meat consumption to a level of twice or three times a week would considerably reduce market pressure. Moreover, almost seven per cent of the meat purchased by German households gets thrown out. Converted proportionally to the total number of animals consumed in Germany this means that 45 million chickens, 4 million pigs and 230,000 heads of beef cattle are needlessly fed and butchered every year. Food waste squanders resources and must be avoided at the very different levels of production, processing and consumption. And then there is agricultural policy as an element of proactive structural policy. Many organic farming associations demonstrate how meat production can be ethical, ecologically benign, and fair. The use of genetically engineered feed is prohibited in organic farming. Indeed, up to 70 per cent of feed must be produced on the livestock producer's farm or come from nearby farms, and the use of antibiotics is highly restricted. These are two core elements that fundamentally change how animals are produced. For the end consumer, organic meat is at least a third more expensive than non-organic meat, but ultimately, for society at large, that is a price worth paying.

Meat demand in the BRICS countries



Mindsets for sustainability – let's start with feed!

Nowadays it is hard to imagine European livestock production without soya-based feed. But this trend has had a massive impact on rural areas in the global South – the bulk of the soya fed to livestock in Europe is imported from Argentina and Brazil. That is not sustainable, says WWF's Birgit Wilhelm, who advocates a change in mindset.

Tofu, soya milk and soya sauce – those are the products we tend to think of when we hear the word soya. But only about one fifth of the soya produced worldwide is used as food. Very few livestock producers grow all the feed for their animals on the farmland they manage; many of the purchased feed compounds contain soya beans as the principal protein component. In Germany, approximately 20 per cent of the imported soya is fed to cattle, 30 per cent to pigs and 50 per cent to poultry. For years now, the highly specialised and export-oriented European livestock sector has been dependent on regular feed imports from South America. As that is where soya beans happen to grow most quickly and cheaply, many farm lobbyists do not consider this a problem. The worldwide division of labour in a globalised agricultural industry solely focused on economic efficiency is being upheld as a model for success. However, it is becoming increasingly evident that this model creates many losers on all sides and that a long-term sustainability perspective is lacking.

Soya production and its impacts

Global soya bean production has more than doubled over the past two decades and there are no signs of this trend abating. The area of land devoted to growing soya worldwide has increased to more than 100 million hectares, i.e. more than three times the territory of Germany. In 2013 more than 30 million tons of soya (mostly from Argentina and Brazil) were imported to Europe. Soya fields are pushing into valuable forests and rare savannahs such as the Brazilian Cerrado, the world's most species-rich savannah and Brazil's most important water source. Soya beans are mainly grown as a monoculture crop, resulting in massive adverse environmental impacts and causing a multitude of social problems. Moreover, there is also the issue of genetic engineering which has been enabling this intensive form of production. While the cultivation of genetically modified soya beans is prohibited in Europe, such soya beans and soya bean meal are being fed to European farm animals.

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The soya bean is a member of the legume family and should not be continuously cropped. It is generally recommended that soya beans should not be grown more than one year in four on any one plot. However, such good farming practices are rarely encountered in South America. In Argentina more than 54 per cent of arable land is devoted to growing soya. Often soya beans are grown twice a year on the same plot. In order to achieve this, the first soya bean crop must ripen early and uniformly. The ripening process is accelerated by spraying herbicides to kill off the soya beans just prior to the first harvest, making the harvesting process quicker and easier.

Disease and weed pressure in the monocultures further increases pesticide usage. The considerable amounts of pesticides as well as fertilisers pollute watercourses and soils. Europe has "outsourced" the cultivation of its livestock feed crops. In the producer countries, a modern and professional soya industry has emerged which produces soya in an economically highly efficient manner. Unfortunately it does not take into consideration the social and ecological aspects of production. Sixty per cent of the soya bean meal produced in Brazil is exported to the EU. While soya which is imported into the EU for biofuel must meet certain minimum criteria under the EU RED (i.e. Round Table on Responsible Soy certification), the bulk of soya that reaches the EU for feedstuff does not have to meet any such criteria. This is a loophole that must urgently be closed. General soya production criteria are called for, no matter whether it ends up on European plates, in fuel tanks, or feed troughs.

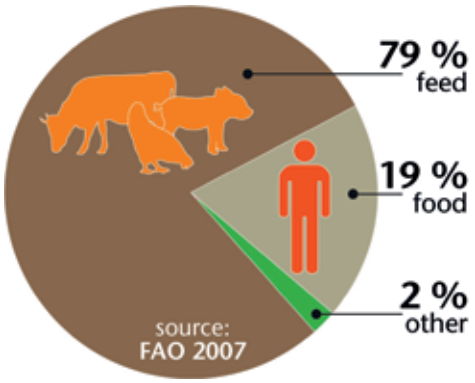
We need more sustainable feeding systems – but how?

Mindsets in livestock farming must change as well. One of the key requirements for moving towards more sustainable farming are limits on stocking rates both per hectare and holding. Stocking rates based on the land area required to meet the animals' feed needs would be advantageous at many levels: Farms would produce the necessary

feed on their own land and the slurry they produced would not become problem waste. On the contrary, the valuable nutrients would be available to the plants and the risk of excess fertiliser use would be reduced.

Sustainability considerations can be integrated into feed purchasing decisions in a variety of ways. The massive imports of cheap soya have displaced indigenous feeds in the marketplace. However, depending on the livestock species concerned, other feedstuffs can be substituted for soya. Suitable alternatives include domestically produced legumes such as peas, field beans or lupines as well as other feed legume crops such as clover and lucerne. From the point of view of animal nutrition this is most easily achieved in cattle feed. Due to their complex ruminant digestive system cows can make optimum use of grasses and produce milk – a high quality food protein source. A study commissioned by WWF has shown that domestically produced grain legumes are a very good substitute for soya bean meal up to an average milk production level of 8,000 kg/year (the current average production level in Germany is 7,000 kg/year). In combination with rapeseed expeller and high-quality forage, grain legumes can also be substituted at higher milk yields. Herbaceous legume crops such as lucerne or clover as part of the forage can also replace the soya meal component in concentrate feeds.

What worldwide soya production is used for



The situation is a little more difficult when it comes to pigs and poultry. Nonetheless, here, too, significant savings of soya bean meal can be made with additions of domestically grown legumes up to a level of 20 per cent of the rations. Studies have also shown, however, that the integration of domestically produced grain legumes and feed legume crops requires fundamental management changes. Moreover, it is frequently argued that domestically grown legumes are not sufficiently available in the marketplace. However, good initial approaches are at hand in terms of on-farm cultivation of legumes on pig-producing holdings as well as legume production under contract.

Transparency – key to greater sustainability of feedstuffs

The example of feedstuffs and the various impacts their production exerts on the environment once again highlights the urgency of moving towards globally sustainable agriculture. While both the soya farmer in Latin America and the pig producer in Germany can contribute to achieving this goal, the responsibility is not theirs alone. The entire value chain including traders, feed mills, processors (such as dairy, meat and poultry processors), retailers and consumers must be called to task.

Responsible decisions can only be taken in the presence of information allowing for real choices. As yet there are no solid figures on the proportion of non-GM soya entering Europe. Estimates suggest that 10 to 20 per cent of the total soya imports are non-GM. While plant-based products containing genetically modified soya must be labelled as such, livestock-based products from animals fed genetically modified soya do not need to be identified. An extension of labelling laws to livestock-based foods would provide consumers with the information necessary to make conscious purchasing decisions.

In addition to freedom from genetic modification, other minimum criteria are urgently needed for greater sustainability in soya production. Two certification systems for soya have come to the fore in recent years: RTRS non GM and ProTerra. It is the view of WWF Germany that both these systems meet the minimum requirements of a first step towards more sustainable soya production. Additionally there is an initiative in the Danube region under the name of "Donausoja" (Danube soya) which similarly meets these minimum criteria. Feed purchasers and traders should require compliance with these minimum requirements as a matter of course. This will only be possible in the presence of chain of custody traceability and transparency.

Many farmers are aware of their responsibility and are already changing their feed ration composition. However, once they do that they have to compete with farmers who continue to bank on cheaper soya feeds. As consumers we can decide what kind of agricultural products we want to buy and whether to eat less meat or better meat and we can thus contribute to more sustainable and more natural farming. Foods produced in accordance with the EU Organic Regulation or based on the standards of organic farming associations should be at the top of the list.

Sustainability needs political support

In the current political and economic environment, farmers who change over to more sustainable livestock feeds are the sole risk bearers of that decision. While the German Federal Ministry of Food and Agriculture supports projects engaged in breeding and cultivating protein crops as part of the Ministry's protein crop strategy, it is clear that the measures are not having sufficient impact. What we need is a change in the policy setting (linking livestock production to forage area; establishing mandatory labelling; etc.) as well as targeted support for legume production in domestic farming with a view to minimising the adverse ecological and social impacts of agricultural production.

China's biomass energy development – a perception change from waste to resource

China has a longstanding tradition of using biogas for decentralised energy supply. Already, there are nearly 42 million household digesters in the rural areas, a figure set to double by 2020. But the country has even more ambitious plans. In order to achieve its own climate targets and raise the share of renewables in overall energy supply to 15 per cent by 2020, it wants to set up 16,000 middle- and large-scale biogas plants. However, implementation isn't quite so easy.

China, with its abundant resources of biomass, has great potential in biogas production. Already in the 1950s, under Mao Zedong, the nation-wide application of household digesters was heavily encouraged to develop decentralised energy supply for remote rural areas. Since then, China's political decision-makers have continued to foster the further utilisation of household biogas applications. So far, about 41.6 million household digesters have been installed in rural areas, the target being 80 million by 2020. These not only supply clean cooking gas, but also create considerable sanitary and health benefits for the rural population by treating their agricultural and household waste.

Since the 1990s, China has put more emphasis on environmental protection and supported the construction of larger biogas plants with technologies such as USR (Up-flow Sludge Reactor), UASB (Up-flow Anaerobic Sludge Blanket) and conventional HCF (High Concentration Flow) to treat liquid waste from livestock or food processing industries as well as from alcohol and beer production. The energetic use of the available biomass was considered more of a side effect and was only marginally utilised at this time. During the last decade, China's approach towards biogas has changed given on-going economic growth and the related need to develop energy resources of all kinds.

China's renewable energy portfolio

The Chinese government aims to cover 15 per cent of its primary energy demand by renewable energy sources by 2020. Here, bio-energy can contribute to the diversification of the renewable energy mix and support a stable base load power. It not only contributes to rural development and decreases local environmental pollution as well as the greenhouse gas emissions but also supports overall development towards a sustainable low-carbon circular economy.

The government states that by the end of 2010, about 45,259 small-scale and 27,436 middle and large-scale biogas plants (digester >50 m^3) existed with a digester capacity of 8.57 million m^3 and an annual biogas output of 1.05 billion nm^3 throughout the Chinese biogas sector. This includes 4,641 biogas plants with digesters of more than 300 m^3. However, middle and large-scale biogas plants, which are explicitly developed

Most large-scale biogas plants are financed by the farmers themselves and tailored to the respective amounts of waste produced.

Photo: Sino-German Biomass Project (FECC/GIZ)

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Photo: Sino-German Biomass Project (FECC/GIZ)

The use of biogas plants is widespread in China, for it is significantly more cost-effective than extending the gas supply grid, especially in remote rural areas.

for energy use, and not solely for anaerobic treatment of wastewater, have only emerged in recent years. In order to utilise the various positives effects and application potentials of bioenergy, the Chinese government has set ambitious goals for its biogas sector. As part of its medium and long-term development plan for renewable energy from 2006 to 2020, the National Development and Reform Commission (NDRC) aims to create 10,000 middle and large-scale biogas plants in the livestock industry and 6,000 industrial wastewater treatment plants with an overall biogas yield of 14 billion nm^3 biogas, realising an installed electric capacity of three gigawatts.

During the last ten years, climate change mitigation emerged as an additional development driver of China's biogas sector. As part of its greenhouse gases emission reduction policies, China signed the Kyoto Protocol in 2002. During the 11th Five-Year Plan, the Chinese government achieved a 20 per cent reduction of CO_2 emission per unit of Gross Domestic Product (GDP). A total of about two trillion Chinese Yuan (CNY) – 240 billion euros – was invested to achieve this goal. In the course of the Copenhagen UN Climate Change Conference 2009, China then announced its 2020 voluntary targets of reducing the intensity of CO_2 emissions per GDP by 40 to 45 per cent compared to 2005 and increasing the share of non-fossil fuels in primary energy consumption to around 15 per cent by 2020.

Making use of a huge potential

Current estimates indicate that usable biomass resources in China alone have the energetic potential to cover about five per cent of China's primary energy. The combined energetic potential of crop residues, energy crops, animal manure, urban household waste and wastewater sludge will lead to a future biogas potential of about 440 billion nm^3 in 2030, or an installed capacity of about 71 GW. According to current estimates of the total yearly biomass energy potential in 2030, crop residues, including by-products, will represent the largest share at 50 per cent of the total biogas potential. Cultivated energy crops on marginal land are estimated to reach 40 per cent of the total biomass energy potential by 2030. Animal manure could contribute nine per cent of the future biogas energy, while simultaneously reducing environmental pollution in rural areas. Biodegradable and municipal sewage waste could add another seven and three per cent respectively.

Regarding the Chinese greenhouse gas (GHG) emission reduction goals, the utilisation of the described biomass resources as a substitute for fossil fuels as well as through replacing chemical fertiliser through biogas plant effluent as organic fertiliser is estimated to lead to a yearly emission reduction potential of CO_2 equivalents of 4.75 billion tons by 2020 and seven billion tons by 2030.

Finding the appropriate incentives

In order to increase the overall capacity of its biogas sector, the Chinese Ministry of Agriculture (MoA) invested more than 24 billion Chinese Yuan (CNY) from 2000 on via construction subsidies for biogas plants. These subsidies covered up to 50 per cent of the total investment and were granted to the respective investors, who are typically also the owners of large-scale agricultural enterprises. Since biogas plants, such as complete stirring tank reactors (CSTR), are generally more costly than traditional wastewater treatment plants, the construction subsidy was intended to create an opportunity for farmers to become energy producers instead of just treating their waste. Additionally, in accordance with the Renewable Energy Law from 2006, feed-in tariffs were set at 0.25 CNY/kWh (0.03 EUR/kWh), on top of the local coal power generation price. In order to receive the financial benefit, a minimum of 500 kWh installed capacity has to be fulfilled to gain access to the grid. But since the connection to the grid comes with great efforts and costs for the national grid operator in most cases, there have only been four successful cases in China so far.

With hardly any opportunities to sell the energy generated to the official grid, this lack of access to the energy market led to an overall underperformance of the existing biogas plants. However, since the construction subsidy was in place, the farmers saw the opportunity to minimise their

costs to treat their agricultural waste by investing in the subsidised technology "biogas". Even though this resulted in a construction of a great number of plants, their operating performance rate was very low. Looking at estimations of the financial feasibility of biogas plants in China, under consideration of a realised grid connection as well as the existing feed-in tariff as an additional revenue stream, this amount was obviously too low and would not provide enough support to enable a financially feasible biogas plant. Hence the Chinese policy-makers developed a variety of adjustments to the existing support policies to further enhance biogas sector performance.

Enhancing performance

One aspect was the establishment of a new category of "super-large" biogas plants with a fermenter volume of more than 5,000 m^3. Rarely realised in China so far, these large-scale applications are now moving into the focus of the future development to apply high-tech technology solutions in a most efficient technical and financial way.

Further, the concept to support the initial investment through a construction subsidy is losing its traction and thus, the political discussion is increasingly focusing on a performance-oriented output subsidy. The currently discussed support scheme considers a subsidy of up to 0.9 CNY per produced nm^3 biogas to create a strong financial incentive for the biogas producers to increase and optimise their biogas production. Still, this kind of subsidy scheme requires a centralised monitoring system that not only provides detailed and reliable data on the actual biogas production of each individual plant, but also resists attempted fraud. Looking at examples from Europe, China is currently developing such a system. It is expected to operate soon. Regarding the lacking access of biogas plants to the official electricity grid, the national state operator vowed in February 2013 to surpass the original goal and foster the connection of not only larger and super-large biogas plants, but also smaller biogas applications throughout China.

In the meantime, the Chinese biogas sector also started to develop its own solutions to overcome existing market barriers. The sector's stakeholders are increasingly focusing on the purification of biogas to produce biomethane to be fed into the official gas grid, or even into self-operated mini-grids, supplying gas to the surrounding rural and small-town households. Here, the Minhe Phase II biogas plant in Penglei, Shandong province is a prominent example. With membrane purification technology, a most innovative approach in China's biogas sector, Minhe II aims to process 60,000 nm^3 biogas per day into biomethane, which shall serve as a substitute for natural gas vehicle fuel. This approach offers independence from the national electricity grid while promising higher revenues than electricity production since natural gas is far more expensive than electricity in China. That is why purified biogas can generate higher revenues for the individual biogas plants without limiting access to the currently discussed performance-oriented subsidy scheme, based on biogas output.

Outlook

Changes already made in the political framework as well as the adaptations currently under discussion promise to have a positive effect on the overall development of the Chinese biogas sector. This will increase the installed capacity, technical sophistication, output-oriented efficient operation and financial feasibility of investing in a biogas plant. Options for business and research co-operation are expected to increase given the on-going strengthening of international agreements (also see Box), offering a benefit for the Chinese biogas sector as well as for foreign enterprises entering the Chinese market. The new developments also offer the opportunity to make more use of resources such as energy crops from marginal land or the creation of additional products such as biogas plant effluents as organic fertiliser.

Not only can the utilisation of agricultural waste as energy resource contribute to environmental protection, but it also bears the potential to support the development of a stable energy supply to rural areas and can therefore serve as important driver of their further economic development progress.

Fostering knowledge exchange and training

China is establishing bilateral co-operation approaches aiming to maintain the link between the Chinese biogas sector and the rest of the biogas world in order to foster the knowledge exchange and adapt international experiences to Chinese conditions. For example, the "Sino-German Biogas Cooperation" based on a memorandum of understanding between Germany and China aims to establish a variety of mechanisms such as a Sino-German biogas research and development centre, a co-operation platform for Chinese and German biogas business operators, a Sino-German demonstration biogas plant, the elaboration of international norms and standards for biogas and bilateral exhibitions on biogas innovations. Establishing these long-term approaches is intended to strengthen co-operation between the two countries in the field of biogas, which is expected to result in a further capacity development of the Chinese stakeholders and business opportunities for the private sector.
The link between education and the actual performance of biogas plants has also been targeted by China's policy-makers, who are focusing on training qualified staff. A curriculum for the professional education of large-scale biogas plant technicians was developed in 2013 to support efficient biogas production in the future. During the development of the curriculum, the Chinese legislator was assisted by international experts as well as Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), who were engaged in the compilation of the curriculum itself and in running initial first trainings. About 300 technicians have since been trained.

Unleashing the potential of family farming

Converting from subsistence to market-oriented farming can increase income. Thanks to the 'Enabling Rural Innovation' approach, family farmers in Uganda and Tanzania have succeeded in improving production and fetching better prices for their produce while safeguarding food security and sustainable management of natural resources. The recipe for success is that farmers take the development process in their own hands.

Godfrey Kaddu lives in Kigaya village in Central Uganda. He used to work as a trader in a retail shop. When his family was expanding to 13 children, he needed more income to pay for school fees and food. Since the trading business did not render enough money, he shifted to farming five years ago. However, despite working hard, his income was still limited by local marketing opportunities. After some years of farming individually, he joined the Twezimbe Farmer Group. The group learned how to conduct a market research and to develop profitable farming enterprises such as selling maize collectively to schools and bigger traders. Last year the group managed to sell maize flour to a nearby primary school for a price of 1,400 Ugandan shillings (UGX) per kg instead of selling cereals for 300–500 UGX to middlemen who buy directly from farmers. In the future the group also plans to sell beans bulked into bigger quantities to schools or other traders who can offer them attractive prices. Furthermore, Godfrey Kaddu is experimenting together with other members from his farming group on drying different vegetables and fruits which they want to bring on the market in the future. The necessary equipment was built by the farmer himself – after he had seen it at a fellow farmer group.

The Enabling Rural Innovation (ERI) approach

The Twezimbe Farmer Group works with Youth Association for Rural Development (YARD), a local NGO in Central Uganda that is one of the implementing partners in the Enabling Rural Innovation (ERI) East Africa project. The regional project is hosted by the Austrian-based NGO HORIZONT3000 and managed from its regional office in Kampala. HORIZONT3000 picked up ERI as a sustainable approach for a market-oriented development strategy for family farmers in two pilot projects in 2009 and started the ERI East Africa project with six local partner organisations in Uganda and Tanzania in 2013. Each partner organisation targets between 40 and 50 farmer groups during an implementation period of three years.

The ERI approach puts farmers in the driving seat – they take the development process in their own hands. In the programme farmers learn how to engage in markets and to develop an entrepreneurial culture in rural areas. Based on the principle 'produce what they can market rather than trying to market what they produce', farmers set up enterprises while safeguarding food security and their natural resource base. Special attention is given to gender balance for marketing as intra-household dynamics have often shown that men take over from women when a crop enters the market.

Godfrey Kaddu built his own equipment to dry fruit and vegetables – having seen it done at a fellow farmers' group.

Photo: T. Pircher

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The process in farmer groups is guided by a set of methods with five core modules: Participatory Diagnosis, Participatory Market Research, Farmer Participatory Research, Participatory Monitoring and Evaluation and Enterprise Development. The methods of these modules were not completely new, but combining them was a novelty when the ERI approach was developed and introduced by the International Center for Tropical Agriculture (CIAT) in 2001. CIAT has developed the approach based on an experience in over 20 years of farmer participatory research, rural agro-enterprise development and natural resource management.

After taking up the approach and gaining initial experience, HORIZONT3000, in co-operation with Trias Uganda decided to consolidate its experiences in a very practical and concise manual consisting of 25 re-printable booklets and visual tools to increase effectiveness and efficiency of ERI trainings. The key players in implementing the ERI project are community development facilitators (CDFs), who are working closely with farmer groups. The CDFs were trained in-depth in all modules of ERI and in facilitation skills needed for working with the farmer groups. In six months of training, intermitted with practical field work, the CDFs were fully equipped with methodological tools for implementing the approach in their project areas.

Starting with what you have instead of what you lack

Some development agents and donor organisations portray family farmers as poor and being dependent on foreign aid. Unfortunately, this picture is even adopted by some farmers themselves, and they do not believe in being successful with small-scale agriculture on their own. The ERI approach aims to overcome the dependency syndrome by acknowledging existing resources and creating visions that farmer groups want to realise in the short, medium and long term. In the 'Participatory Diagnosis' module, farmers identify available natural resources, institutional networks, and specific know-how in training sessions with facilitators. Based on the identified assets, they develop a vision of how they see themselves in the future. This process helps participants to become aware of the current and the desired situation, and to set objectives that they want to achieve. Common objectives include improvements in food security, balanced nutrition, health, sanitation facilities, housing and the purchase of livestock.

The implementation of an action plan, based on the identified objectives, is monitored by a committee within the groups. With knowledge and skills from the module 'Participatory Monitoring and Evaluation', farmers themselves develop key indicators for keeping track of group activities and outcomes towards set objectives. Gender balance in defining these indicators is assured by involving both male and female farmers equally. In the next step, the committee members, together with the group, design simple tools for collecting required information and monitor the progress in a group as well as at a household level. After compiling collected data, they report progress to the other group members. Most farmers perceive the definition of goals as well as monitoring of these as a motivation to work harder.

Exploring markets and new farming practices ...

In the 'Participatory Market Research' module, marketing committees of the group identify and evaluate market opportunities for different products. Based on simple tools, the group members learn to systematically collect market information for different commodities, taking into account required quality standards. The core activity of this module is to visit potential buyers such as hotels, schools, supermarkets, agritraders and food exporters. Not only do farmers learn about prices and product requirements, they also become confident in negotiating prices with customers and establish trade agreements. Carrying out a structured market chain analysis helps them to understand the positions of different actors in the value chain. In a cost-benefit analysis, farmers find out the prevailing production costs and the price needed to make profit with an enterprise. Despite exploring new markets, food security for participating households is given the highest priority when evaluating different options for production. Based on the results, farmers select two potential enterprises they want to engage in.

As some farmers might not have enough experience with selected enterprises, they first gain knowledge in producing respective crops, or they refine their practices in order to fulfil demanded quality standards. In the 'Farmer Participatory Research' module, farmers learn how to design experiments and systematically draw findings from these. Prior to experimentation, farmers learn about the concept of sustainability in relation to the management of natural resources as well its importance for business. Bearing these principles in mind, an experimental committee designs field trials, monitors and analyses them, and gives feedback on their findings to other members. Groups in the ERI East Africa Project are experimenting with different seed varieties and practices for soil fertility management, and they are trying out new technologies such as drying fruits or making soap from oil plants. Some farmers have developed a strong interest in doing their own research, such as Mrs. Betty Kibirango from Central Uganda. She is observing the behaviour of local chicken at her homestead and discusses conclusions, e.g. on the effect of vaccines, with other group members. After carrying out experiments with crops in a group, she was also able to transfer the principles of experimentation to livestock.

... and becoming successful rural entrepreneurs

In a gradual process, the ERI groups gain experience in production and marketing and become rural entrepreneurs. Monitoring tools and self-evaluation activities help them to stay on track towards earlier defined visions

and goals. In the final module 'Enterprise Development', farmers study market intelligence, business planning, and contract management in order to set up strong and sustainable businesses with selected products. With a higher number of producers, more profitable agricultural commodity markets become accessible. Producer associations and co-operative structures play an important role for farmer groups to reach larger quantities and fetch higher prices. Since farmers in the ERI project have full ownership of their enterprises, they define limits themselves.

The Birungu Organic Farmers Association in Hoima district, Western Uganda, has taken the entrepreneur skills to the next level. They worked in an earlier ERI project with CIAT and African2000 Network between 2007 and 2010. When the project ended, the association remained together and hired a two roomed store in the nearby trading centre. They started bulking maize, soya bean and rice produced by individual farmers of the association, which has been growing in the past years and now has several contracts with different grain and seed buyers. A credit scheme around the association helps the farmers to finance their business.

What makes ERI different from other approaches?

ERI overcomes the linear mode of technology transfer; it builds on participatory development and puts farmers at the centre of the development process. It recognises available natural resources as a key asset and focuses on a group learning process, social organisation as well as building up networks to other stakeholders in the value chain – there is no provision of free inputs like seeds, tools or livestock to farmers by implementing organisations. Community Development Facilitators support farmers in establishing links with other stakeholders such as input-dealers, traders and other institutions that might be helpful for them. However, when it comes to negotiations and setting up arrangements for co-operation, farmers themselves take over. Whereas in most contract farming arrangements, where companies actively approach farmers, ERI turns these relationships upside down.

Farmers working with ERI appreciate the approach because it is people-centred and recognises differences in agro-ecology, markets, socio-economic conditions and cultural preferences. Empowering farmers with a methodological approach taps the potential to create tailor-made solutions for improved production and reaching more profitable markets. Farmers learn how to respond actively to changing environments, fluctuations in markets and social organisation. They become researchers and marketing specialists to form their own development process. As one farmer from YARD put it, "[with the ERI project] we have gotten a foundation and confidence, and now we are able to continue by ourselves".

More information:
➤ **www.eri-approach.info**

Betty Kibirango observing the behaviour of local chickens at her homestead.

Photo: T. Pircher

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