RURAL 21
The International Journal for Rural Development
4 | 2020
VOLUME 54
ISSN 1866-8011
D 20506 F

One Health

DEVELOPMENT COOPERATION
Reconciling perspectives to find solutions

INDIA
Community-led natural farming in Andra Pradesh

ZAMBIA
Villagers must make room for Chinese coal mine

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Dear Reader,

On the 15th November 2020, 10 a.m. Central European Time, the World Health Organization reported 53.7 million confirmed cases of COVID-19 and 1.3 million deaths resulting from the disease. Exactly five months before, on the 15th June 2020, what had been the latest SARS-CoV-2 statistics at that time were presented in our Editorial. A total of 8.5 million people had then tested positive for the virus, and over 455,000 people had died as a result of the disease. So over the last five months, the number of deaths has grown almost threefold, while the number of (recorded) infections is now nearly six times higher.

In spring 2019, when nobody even knew the abbreviation Sars-CoV-2, the World Bank cited a hardly less impressive pair of figures at its 2nd International Conference on (re-)emerging infectious diseases. The annual global cost of moderately severe to severe pandemics was estimated at roughly 570 billion US dollars, corresponding to 0.7 per cent of global income, while the World Bank's financial experts put the annual global cost of preparedness at 4.5 billion US dollars. Broken down to the level of the population in low- and middle-income countries, this would amount to 1 US dollar per person per year.

These figures were taken from a report presented by the International Working Group on Financing Pandemic Preparedness (IWG) in 2017. The IWG had been set up by the World Bank in 2016 in response to reports in the aftermath of the Ebola crisis, the key lesson learnt being the urgent need to strengthen and scale up investments in global health security. In their 2017 report, the IWG experts sum up the burden of large epidemics: 1) health impacts such as sickness, deaths, long-term sequelae; 2) economic impacts such as productivity loss from death or disability, loss from travel/transport bans; loss of consumer confidence and spend; absenteeism and closure of schools; cost of response and recovery; and 3) social impacts such as loss of social fabric; inequities (women, children, poor people); erosion of trust in institutions. For some months now, all of these aspects have been painfully perceived by the world as a consequence of the corona pandemic.

In July 2020, the International Monetary Fund's Chief Economist Gita Gopinah put the economic impacts of the pandemic at 9 trillion US dollars between 2020 and 2021. Compared to this figure, the 570 billion US dollars mentioned in the IWG's 2017 report seem almost ridiculously small. Of course we know that such numbers can only be approximations. But a precise sum is not really necessary, anyway. For what we can be absolutely certain of is that the pandemic will reverse the progress made since the 1990s in reducing global poverty und will increase inequality. And that is the really bad news.

We haven't devoted this edition of Rural 21 explicitly to the Covid-19 pandemic, for none of our contributions would now be conceivable without it in any case. Rather, we have chosen to present you a health concept which has gained considerable momentum in the course of the Sars-CoV-2 crisis. "One Health" sets out from close cooperation between human and veterinary medicine. The approach is based on the insight that zoonoses, i.e. diseases that can be transmitted from animals to humans (such as brucellosis, rabies and, presumably, Sars-CoV-2, too – of which there is, as yet, no proof, as you can read in this edition) can be predicted, prevented and controlled much more quickly and at a lesser cost than if the two disciplines are working separately. But the One Health concept also implies that human and animal health are intrinsically linked to the health of our environment. In other words, it is a comprehensive approach that reaches way beyond tackling infectious diseases.

Our authors give accounts of how the One Health concept evolved, how it has since further developed and in which contexts it can be applied; what we know about interrelations at the animal-human-environment interface – and what we (still) don't know; how One Health research, capacity building und implementation intermesh, and why we should consider food systems in this context; and how we can use the approach to counter future pandemics. For the saying that German physician Christoph Wilhelm Hufeland already coined in the 18th century – "prevention is better than cure" – holds true more than ever. It might only be a matter of time before we find ourselves having to deal with Sars-CoV-3.

We wish you inspiring reading.

On behalf of the editorial team,

Silvia Richter

You can find the latest information on COVID-19 at **www.rural21.com**

Imprint

Rural 21 –
The International Journal for Rural Development

Published by:
DLG-Verlag GmbH
Frankfurt, Germany

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Silvia Richter, s.richter@dlg.org

Editorial staff / Frankfurt office:
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Angelika Wilcke, a.wilcke@dlg.org

Editorial assistance:
Mike Gardner

Translated by:
Christopher Hay, Tazir International Services

Cover photo:
Juan Manuel Castro Prieto/ laif

Design & Layout:
Andrea Trapani, DLG-Verlag

Editorial office, distribution, advertising:
DLG-Verlag GmbH
Eschborner Landstraße 122
60489 Frankfurt, Germany

Printed by:
Brühlsche Universitätsdruckerei GmbH & Co KG
35396 Gießen, Germany

Rural 21 is published four times a year.
The subscription rate is EUR 33.– (Germany), EUR 37.– (EU countries), EUR 51.– (non-EU countries) and EUR 8.30 per issue, plus postage.

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One Health – towards a more inclusive science

How can we move in the direction of a modern theory of health that has the ability to face the new complex challenges of global change? The One Health concept suggests that health must be viewed as the area of impact of human actions within human-environmental systems. For not only the COVID-19 pandemic shows that humans are inescapably related to their environment, which also includes wild animals and domestic animals. This calls for a systemic view, according to our author.

By Jakob Zinsstag

In 1997, Marcel Tanner, the then director of the Swiss Tropical and Public Health Institute (Swiss TPH) asked me whether, as a veterinarian, I could take a look at the health care of mobile pastoralists (nomadic and transhumant livestock keepers) and their animals in Chad. This mostly nomadic population group falls through the mesh of the Chadian health care system and is completely undersupplied. On this occasion, I remembered my doctoral supervisor Hans Fey, a professor of microbiology at the University of Bern's Faculty of Veterinary Medicine, in Switzerland, who introduced me to the term "One Medicine". Coined in the 1960s by American epidemiologist Calvin Schwabe, it says that there is no paradigmatic difference between human and veterinary medicine and that both share the same scientific principles.

Photo: Jörg Böthling

From "One Medicine" to "One Health"

In 1998, as part of a project supported by the Swiss National Science Foundation, an interdisciplinary team of human and veterinary medical staff started to investigate the health of people and their animals on the south-eastern shore of Lake Chad. To our surprise, we found that more animals than children were vaccinated. In a participatory transdisciplinary process with representatives from the population, authorities and science, we agreed on the implementation of common vaccination campaigns for humans and animals. When the veterinarians started organising vaccination campaigns for animals, they took human medical staff with them in the same vehicle. While the vets vaccinated cows, the health workers vaccinated children and women and provided people with medicines and conducted health training, giving a population group previously excluded from care access to health services. The shared use of the cold chain and transport also saved time and money compared to separate services.

This work was the starting point for our theoretical and methodological development from "One Medicine" to "One Health", with a stronger emphasis on public health and disease prevention. One Health promotes cooperation between representatives from science, authorities and the population. This increased communication helps not only to gain a deeper understanding of the situation, but also to develop better solutions that are supported by all stakeholders and can therefore have a lasting effect. "One Health" therefore means an added value for the health of people and animals and is attractive for health authorities thanks to the financial savings in healing and disease control costs. This is achieved through closer, interdisciplinary and transdisciplinary cooperation on a par between human and veterinary medicine, other natural sciences and the humanities.

Efficient, cost-saving and universally applicable

How can the added value of closer cooperation between human and veterinary medicine be shown? With statistical methods, we can demonstrate that with an interdisciplinary approach, the source of zoonoses (diseases that are transmitted from animals to humans) can be found much more quickly than when humans or animals are examined on their own. Using mathematical models and economic analyses, we see that zoonoses such as brucellosis and rabies can be controlled and eventually eliminated at lesser cost if we contain them in reservoir animals instead of just treating affected people. The joint investigation of schistosomiasis in humans and cows in Côte d'Ivoire showed us a previously neglected high proportion of hybrid forms between animal (*Schistosoma bovis*) and human (*Schistosoma haematobium*) parasites in humans. This demonstrates how a zoonosis can develop with unrestricted contact between humans and animals.

One Health approaches are not limited to infectious diseases, but can also be used in many other contexts, for example in rehabilitation therapy. Together with psychologists, we developed and examined animal-assisted therapies for patients with brain injuries, in which the well-being of the animals used is just as important as that of humans. In cooperation with microbiologists, we can show that keeping pets in retirement homes does not lead to a risk of antibiotic-resistant bacterial diseases in humans, but that dogs and cats contribute to human wellbeing. Together with cancer epidemiologists, we investigated the conditions for a joint registration of tumours in humans and dogs. Since dogs often develop tumours more quickly than humans in their lifetime, they could be important in monitoring environmental risks to humans.

Adapting health interventions to local ways of living and thinking

The health of humans and animals is strongly influenced by social, cultural and linguistic factors. If we involve sociologists, anthropologists, linguists and cultural scientists on an equal footing in research planning from the start, we can take these influences into account more precisely. In Guatemala, we managed to enter into a dialogue between Maya healers and biomedically trained doctors. This dialogue showed that the differences between the respective approaches to creating knowledge (epistemologies) were simply too great to form linkages. However, we did recognise the importance of letting patients choose their health care system without forcing them into a conflict of loyalty between different medical systems. In this way, their spiritual, emotional and physical health needs can be better considered at the same time (see left Photo on next page). This dialogue is welcomed by the Maya healers. It is just the beginning, and can be continued with mutual respect.

In northern Mali, a Swiss cultural scientist was able to collect more precise data on the health of Tuareg women than a Malian doctor. This was the case because, apparently, the gender difference represents a greater barrier to communication about health and reproduction than differences in national origin. In the same context, a precise linguistic analysis of word meanings in local languages showed that the loss of knowledge and understanding (epistemicide) can (and must) be prevented through an interest in other ways of thinking and that a common language (lingua franca) should be used carefully.

In rural population groups in Chad, new conceptualisations of "access to health care" and

Maya healers and biomedically trained doctors discussing an intercultural, intersubjective consensus in Peten, Guatemala.

Photo: Jakob Zinsstag

A Maya healer talking to the author about a common understanding of a chicken's disease in Peten, Guatemala. Photo: Swiss TPH

"socially layered resilience" by medical anthropologist Brigit Obrist were groundbreaking in gaining a better systemic understanding of the barriers to the implementation of health interventions. We elaborated these approaches into mixed quantitative-qualitative methods which showed that health interventions in different countries must be adapted to local ways of living and thinking in order to be effective – not the other way around. Generally speaking, these experiences have taught us how a more integrative science creates a gain in knowledge that could not be generated without cooperation.

Involving the population and authorities

In all of our One Health projects, we maintain intensive partnerships with local research institutes and universities in accordance with the guidelines of the Commission for Research Partnerships with Developing Countries (KFPE) of the Swiss Academy of Natural Sciences. The development of health care cannot be limited to the academic field, but must include the population and authorities in the co-production of implementation knowledge. Although many participants in such processes have no formal training, they are nonetheless experts who bring knowledge that is often hidden from purely academic approaches. In this way, in iterative, participatory stakeholder meetings, we can develop effective health care in a very targeted manner which is feasible for the authorities and acceptable to the population (also see articles on pages 14 and 22).

Moving towards a modern theory of health

Although more integrating and systemic approaches to health have emerged recently, we are observing an accelerated fragmentation of human and veterinary medicine into a growing number of sub-disciplines, which repeatedly leads to misinterpretations. The exponentially growing specialist literature cannot possibly be surveyed by individuals.

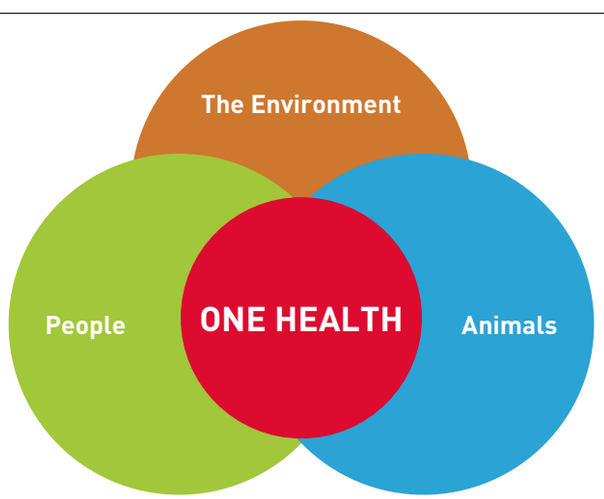
At the same time, we are observing, especially using the example of COVID-19, how complex the relationships and dependencies between people, animals and the environment are. How can we move in the direction of a modern theory of health suited to face the new complex challenges of global change? Health must be viewed as the sphere of influence of human actions within human-environment systems or ecosystems approaches to health. We also speak of "health in social-ecological systems" (see lower Box on next page).

This perspective includes scaling of systems biology aspects from the molecular and cellular level up to human and animal populations, which helps us understand health explicitly as a consequence of processes in complex human-environment systems. This also includes unpredictable, emergent phenomena (emerging diseases) in the sense of Alfred North Whitehead's process philosophy. For example determining the origin of the current COVID-19 pandemic to be able to prevent such outbreaks in the future (see upper Box on next page).

The inescapable relationship between humans and their environment

The "One Health" concept considers the health of people, animals and their environment together and thus transcends people's traditional anthropocentric perspective. It keeps an eye on the wellbeing of both people and wild and domestic animals in their environment. So it is really about the inescapable relationship between humans and their environment, which includes animals. Such a broader approach is

THE ONE HEALTH TRIAD



also reflected in the remarkable current initiative to bring animal health and animal welfare to the United Nations by means of a UN convention. This makes it clear that concepts addressing the mutual dependence and influence of humans, animals and the environment, to which One Health belongs, find resonance in a wide variety of academic disciplines such as philosophy, cultural studies, anthropology and law.

Contribution to societal problem solving

Of course, reductionist, basic research is still required at the forefront, especially for the development of new antibiotics or vaccines. But complementary to this, we need more integrating systemic approaches which have the overall social perspective in view and include academic, political and civil actors in finding solutions.

The Organisation for Economic Co-operation and Development (OECD) recently approved a report on the promotion of transdisciplinary research. The report recommends the governments of the member states to use sustainable resources for transdisciplinary research and to involve the public and private sectors in this. Research funding institutions should develop new criteria for the quality of transdisciplinary research and programmes for their funding, while universities should offer modules for training in transdisciplinarity and promote the careers of young women scientists in this field.

Who would have guessed that the study of nomads and their animals that began 23 years ago would open the way to a systemic view with a transdisciplinary approach? Whenever we go down such a path, far-reaching consequences for an inclusive and interwoven science can arise.

Jakob Zinsstag is a veterinary epidemiologist. He is deputy head of the Epidemiology and Public Health department at the Swiss Tropical and Public Health Institute (Swiss TPH), an associated institute of the University of Basel.
Contact: jakob.zinsstag@swisstph.ch

This article is based on a contribution by the author to the bulletin "Lebensräume/Lieux de vie", 2/20, published by the Swiss Academy of Humanities and Social Sciences (SAHS).

References: **www.rural21.com**

WHY TRANSDISCIPLINARY APPROACHES ARE NEEDED – THE EXAMPLE OF COVID-19

The importance of transdisciplinary approaches can be shown well using the example of the COVID-19 outbreak. Epidemiologists and virologists claim the scientific authority to interpret the current pandemic, but not to recommend how society should deal with it. Governments and scientists cannot solve this dilemma on their own. All actors have interests they are pursuing, so a social consensus can best be achieved through a participatory (transdisciplinary) process including representatives of all interest groups.

Most of the Corona viruses have been found in wildlife and livestock. Only few Corona viruses have adapted to humans. Some of the animal viruses in cattle, dogs and humans are genetically close to SARS-CoV-2, the virus causing COVID-19. It is possible that the exposure to animals carrying Corona viruses may elicit a cross-protection against COVID-19 infection and the severity of the clinical course. More research is needed to elucidate possible cross-protection between human and animal Corona viruses.

From a One Health perspective, human, domestic animal and wildlife disease surveillance should be integrated and closely communicated. Integrated surveillance-response systems show that the earlier a zoonotic agent is detected in the environment, in wild animals or domestic animals, and the better the monitoring data for humans, animals and the environment are communicated with each other to prevent an outbreak, the lower the cumulative cost will be. The ongoing COVID-19 pandemic is a striking example in which early detection was missed in wild or domestic animals. There is an urgent need to get to know better the interfaces of the transmission of pathogens between the environment, wild animals, domestic animals and humans as part of a complex human-environmental system (or social-ecological system [SES]).

In order to prevent further pandemic risks through the use of integrated human – animal surveillance-response systems on a global level, we also urgently need to investigate the biosecurity of live animal markets, intensively bred chickens or pigs and other farm animals as well as the risks of transmission between wild and farm animals. To improve biosecurity in live animal markets and on farms, animal welfare needs to be fundamentally changed. Animals are often kept, transported and slaughtered under unacceptable hygienic conditions. At the same time, we must not forget that animal husbandry contributes to the livelihood of hundreds of millions of smallholders. Drastic control measures can lead to loss of income and lead to poverty and hunger. For this reason, all stakeholders (e.g. farmers, traders, butchers, consumers, administrators and scientists) should be involved in developing locally adapted biosecurity and animal welfare measures while maintaining economic activity.

HEALTH CONCEPTS AT A GLANCE

One Health is, in the first place, at the intersection of human and animal health, aiming to demonstrate a benefit from a closer cooperation of human and veterinary medicine. Clearly, large sections of separated human and animal health do not require a One Health approach. Broader approaches, considering interactions of health and the environment, within social-ecological systems (SES) comprehend One Health, which is thus embedded within ecosystem approaches to health (**EcoHealth**), for which a newer term, "**Health in Social-Ecological Systems**" (HSES), has been coined. SES are most often delimited by a given context of a country or a region. One Health includes social and environmental (ecological) factors, reaching beyond the strict limits of public and animal health.
Planetary Health conceptual thinking aims to identify co-benefits across targets, but remains centred on human health and does not explicitly include animal health. Planetary Health can be seen as a historical extension from global health and international health. It attempts to demonstrate linkages of global environmental change and health, which are hard to prove, based on the inherent data variability, confounding factors, and the duration and scale of the phenomena. We argue that One Health should still be at the centre of interest, building inter-sectoral cooperation from the inside and gradually expanding it to more complex issues and health security hazards across the whole of the SES, as the evidence base for its effectiveness matures.

Contact between animals and humans and their waste can be a disease threat.

Photo: Lian Thomas

Countering the double-whammy of zoonotic diseases

Estimates put the number of people dying from endemic zoonoses at more than two million each year. Those affected above all belong to the low- and middle-income strata of society who have already been overlooked by both policy-makers and healthcare providers. Our authors give an overview of the key drivers of zoonoses and show how the One Health approach can help to control and prevent zoonotic diseases.

By Lian Thomas, Grace Patterson, Lucy Coyne and Jonathan Rushton

A zoonotic disease (zoonoses) can infect both animals and people and be transmitted between vertebrate animals and people. Of the known (approximately 1,400) human pathogens 60 per cent have come from diseases that were first in animals. This historical trend has accelerated recently; of the newly emerging diseases in people approximately 75 per cent are believed to have come from animals. The virus that causes COVID-19, SARS-CoV-2, is the most recent example of a pathogen in animals then infecting people.

The magnitude of the problem

COVID-19 emergence has created the world's first true pandemic for a hundred years. We are currently experiencing first-hand the health and economic burden of a pandemic born of a zoonotic 'spill-over' event. Zoonotic spill-over, the evolution of a pathogen from being wholly adapted to transmission between non-human animals to becoming wholly or partially adapted to humans, appears to be increasing in frequency. COVID-19, one of the most visible examples of zoonotic spill-over in recent history, follows the relatively recent emergence of Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS), Nipah virus, 'Swine Flu' and Highly Pathogenic Avian Influenza (H5N1), among others, as illustrated in the timeline on opposite page.

The significance of zoonoses with pandemic potential will not be lost on any readers; the huge cost in terms of human life and the economic shocks wrought by our response to this virus have firmly placed the risks of emerging diseases of zoonotic origin in the front and centre of public consciousness. The economic costs alone of emergence events are substantial, with six major zoonotic outbreaks occurring between 1997 and 2006 estimated to have had a combined economic burden of 80 billion US dollars. The final bill from the current COVID-19 pandemic will be in the trillions of dollars, alongside the significant health and mental suffering. In addition to the COVID-19 burdens, there are communities where other endemic zoonotic diseases that circulate constantly in people and their animals cause frequent and regular negative impact on economics, health, and wellbeing.

It is estimated that over two million people die yearly from endemic zoonoses. Millions more suffer from debilitating, chronic conditions that reduce their quality of life and their economic prospects, and often bring social isolation or stigma. The burden of zoonotic disease has been described as a 'double-whammy' where the human health impacts are exacerbated by losses suffered within the livestock sector, such as reduced productivity, livestock deaths, and the costs to farmers to control or treat these diseases. The burden of these zoonoses and of foodborne illnesses is felt predominately in low- and middle income countries (LMICs), within communities with least resilience to health and economic shocks. Endemic zoonoses are highly correlated with poverty by dint of their association with close contact between humans and livestock, poor sanitation, and inadequate access to preventative and curative health care. Consequently, these 'neglected diseases' of 'neglected populations' have his-

torically been overlooked by policy-makers and healthcare providers alike.

What is driving the emergence of zoonotic diseases?

The chief causes of zoonotic spill-over and transmission within populations are many and varied; yet key drivers can be identified related to the increasing frequency of spill-over events, transmission of zoonoses and emergence of antimicrobial resistance (AMR) as illustrated in the Figure on page 10. We can look at these drivers through the lens of our globalised food system and highlight aspects of current consumption, marketing and production of our food related to accelerating these events.

Our growing and increasingly urbanised and affluent human population is driving an unprecedented expansion of agricultural production, specifically an increasing demand for animal-source foods. The location of the animal production units needed to meet this demand, or of the crop-lands required to provide feed input to these units, requires large-scale land use change, potentially encroaching into wildlife habitats and increasing the opportunities for contact between wildlife and humans or domestic livestock. It is estimated that between 2019 and 2050, up to one billion hectares of land will be newly converted into agricultural production. Alterations in vector distribution are also driven by other land-use changes such as widespread irrigation for rice crops, exacerbated by anthropogenic climate change (to which agriculture is a major contributor), resulting in increasing transmission of vector-borne diseases. Changing land-use and rainfall patterns appear to be responsible for altering temporal patterns of outbreaks of the mosquito-borne Rift-Valley Fever, whilst the mosquito vector of chikungunya and dengue, *Aedes albopictus*, has broadened its range northward, leading to the recent report of the first locally-acquired case of dengue in Italy.

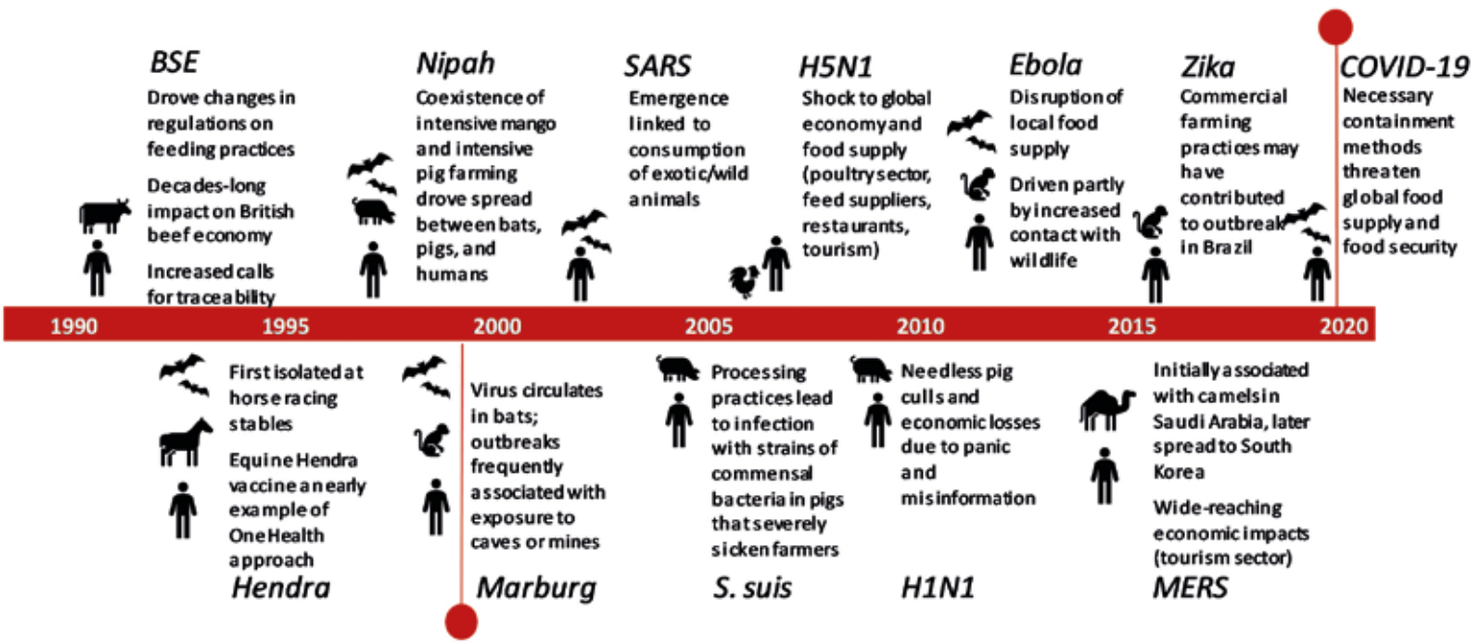
Inadequate biosecurity practices along value chains provide opportunities for incursion of novel pathogens into the increasingly highly intensive system within them. Under intensified production systems, a high number of often genetically homogenous livestock species, or farmed-wildlife species, are kept in close proximity, potentially under conditions of physiological and psychological stress within which disease transmission between animals can be facilitated. Those working closely with these animals are at a high risk of acquiring infection with newly emerging diseases of animal origin.

The 1998 emergence of Nipah virus (NiV) in the Malaysian peninsula is an example of a virus arising from a wildlife reservoir (fruit bats) coming into contact with domestic livestock, through the co-existence of intensive mango and intensive pig production. This virus began circulating within the pig population and outbreaks of the virus, causing severe neurological disorders and with a 40 per cent fatality rate, occurred in workers in direct contact with infected pigs. Bat to human (via contaminated fruit) and human to human transmission has since been reported in Bangladesh and India. Similar co-existence of intensive poultry production with large populations of wildfowl harbouring Influenza H5N1 led to its emergence in China.

Intensification of livestock production has been historically heavily reliant on the use of antimicrobial agents for the prevention and control of disease often on a whole-herd/flock basis and, at sub-therapeutic levels, as antimicrobial growth promoters (AGPs). The sub-therapeutic use of antimicrobials results in selective pressure for resistant bacterial strains and agriculture-associated antimicrobial resistance (AMR) is of increasing concern worldwide, as we are seriously faced with the potential of a post-antibiotic future.

The onward processing, marketing and consumption of animal-source foods, both domestic livestock and wild-caught or farmed wildlife species, can also be responsible for potential zoonotic transmission events. It is hypothesised that the virus that causes COVID-19 was originally a pathogen of pangolins, the most extensively trafficked wild mammal in the world today, and the wet market, with its multitude of disparate mammalian species, provided the ideal environment for adaptive changes resulting in the sustained human-to-human trans-

Timeline of significant emerging zoonoses outbreaks over the past 30 years



Listed at year of emergence or highest impact with animals affected and/or reservoir animals. BSE = Bovine Spongiform Encephalitis, S. suis = Streptococcus suis

mission we are now experiencing on a global scale.

The speed of introduction of novel pathogens into multiple countries is obviously highly correlated with the globalisation of travel and trade, as people, foods, animals and objects can travel across the world in a day. Our globalised supply chains involve food products undergoing processing stages in multiple countries or even continents, and in each location being exposed to pathogens. The Figure demonstrates some of the drivers of zoonoses and antimicrobial resistance

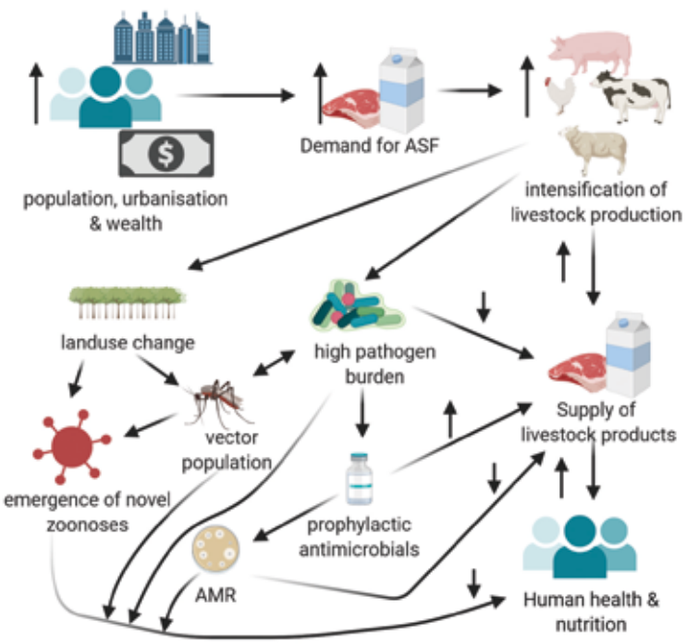
What can be done to predict, prevent and control zoonoses?

One Health, the concept that the health of humans, non-human animals and the environment is intrinsically linked, encourages us as a community to think and act in a multi-sectoral, multi-disciplinary way. The concept is multifaceted and, at its broadest, can be applied as a lens to many of the world's health and environmental problems, but is highly applicable to the control and prevention of zoonotic disease. Fewer human health practitioners will now say 'zoo-what?' when zoonoses are mentioned, and there will be no turning away from the urgent need to improve our ability to detect and respond to zoonotic spill-over events, but a greater degree of One Health thinking and acting is necessary to have substantial impact on emerging and endemic zoonoses and the ever present threat posed by antimicrobial resistance alike.

Preventing zoonotic spill-over, reducing transmission events and mitigating the health and economic impacts of these threats require a paradigm shift in the way we organise and legislate our food systems (see also article on page 35) and the structure of our animal and human health systems.

Improved multi-disciplinary training is required for professionals within human, animal and environment health to allow for ease of communication between sectors. One Health student networks and specific training in One Health have sprung up globally in recent years, a trend which must be sustained and indeed accelerated. While the diagnosis and treatment of zoonotic diseases will be improved both through increased awareness by frontline workers, it also requires accelerated development of appropriate diagnostic tests which should be affordable and easy to apply, particularly in resource-constrained settings.

Interaction between intensification of livestock production, zoonoses & antimicrobial resistance



ASF = animal-source food

Created with BioRender.com

There is growing evidence of the need to conduct control programmes for zoonoses in a One Health manner, targeting pathogens in both the human and non-human hosts and the environment or vector species. It is essential that healthcare services take an integrated approach, whereby these control programmes are cross-sectoral and instead of being primarily 'vertical' programmes, which focus on a single pathogen, they encompass a wider range of pathogens. This will improve the efficiency of programmes and lead to more sustainable outcomes. Identifying and capitalising on synergies, such as between the control of zoonotic and non-zoonotic helminth infections through water and sanitation (WASH) programmes and mass drug administration (MDA) programmes, is a first step in developing more co-ordinated and cost-effective control programmes.

Disease surveillance systems allowing for the integration of data from the human, animal and environment sectors are an important aspect of both early-warning for novel emergence events but also for the prioritisation and control of endemic zoonoses, foodborne disease and antimicrobial resistance. Ensuring interoperability between systems set up for use by individual sectors will allow for faster response to disease events, facilitate inter-sectoral understanding and co-operation and eventually improved data sharing at international level through full engagement with the global health security agenda and the international health regulations. Models for such integrated systems exist, such as the Danish programme for surveillance of antimicrobial consumption and resistance in bacteria from farm animals, food and humans (DANMAP). Extensive evaluation of such systems, including the legislative and budgetary changes necessary to implement them, is critical if they are to be replicated across many countries. Ensuring that environmental data is also integrated into these systems is the next crucial step in creating truly 'One Health' systems. Appropriately allocating surveillance resources into the prediction and prevention of zoonoses can be improved through the use of risk-mapping activities integrating socio-economic indicators, land use change, climatic data and host density and diversity.

Undertaking surveillance and control programmes and improving treatment of zoonoses is only one side of the coin. If we are to truly mitigate the burden of zoonoses in all their forms, we must simultaneously concentrate on addressing the underlying drivers. As a global community, we have to address sustainability of agricultural value chains and make health the central focus of our agri-food policies, including those relating to land-use planning, pharmaceutical use within livestock production, biosecurity, irrigation and waste management. These changes will also involve fundamental shifts in consumer perceptions and demands. Structural changes are needed to improve access to animal-source foods to those whose diets are fundamentally deficient in the valuable proteins and micronutrients they provide, whilst moving many of the world's more developed economies back towards predominantly plant-based diets as recommended by the *Lancet*-EAT Commission.

Defining prioritities is key

All of the steps above will require strong political will to create the enabling environment for

LITTLE GLOSSARY

An **endemic zoonotic disease** is one which circulates at a consistent level within the community, being transmitted between animals or through contact with animal-source products and humans. Examples include bovine tuberculosis, a bacterial disease of cattle related to the agent causing human TB which can infect humans and cause many similar symptoms, brucellosis, a bacterial disease causing malaise, joint and muscle pain and a relapsing fever, and neurocysticercosis, a brain infection caused by the intermediate, cyst, stage of the pork tapeworm, which is a leading cause of acquired epilepsy in regions where the parasite is present.

Foodborne diseases are those following the ingestion of food contaminated with bacteria, viruses, parasites or chemical toxins. World-wide, the majority of foodborne illnesses are diarrhoeal diseases caused by agents such as *Salmonella* spp., *Campylobacter* spp. and Norovirus.

Vector-borne diseases are those transmitted to humans by the bite of an arthropod vector such as ticks, lice, mosquitos and fleas. Some may be transmitted by the vector between humans, such as Dengue and Malaria, while others may be carried by the vector from animals to humans, such as Lyme disease and Rift Valley Fever Virus.

change, including the provision of adequate resources. Methodological prioritisation of zoonotic disease is necessary to identify greatest threats, formulate action plans and justify spending. To ensure accurate assess of impacts and risk, input is needed from sectors beyond animal and human health, including agents involved in environmental health, business, trade and government. The US Centre for Disease Control (CDC) leads OHZDP (One Health Zoonotic Disease Prioritization) workshops to help entities prioritise their top zoonotic diseases of greatest concern and develop One Health oriented plans to address identified diseases. This process brings together representatives from animal, human, and environmental health and stakeholders from multiple sectors. The process involves five steps: selection of stakeholders and zoonoses to be ranked, development of 5-8 key criteria, development of a single categorical question per criterion, ranking of criteria, and ranking of zoonoses based on answers to weighted criteria. This process uses qualitative, semi-quantitative and quantitative methods to achieve these ends.

This tool was developed to meet the needs of those working in areas where quantitative data on zoonoses are scarce and ties between human and animal health are underutilised. It also facilitates equal input from all invested stakeholders, accommodates diversity of location, scale and purpose, acknowledges data limitations, and is quick to increase action. Since its launch in 2014, 25 states, regions and countries have conducted an OHZDP alongside CDC facilitators. Sixteen of these assessments have been conducted in Africa, but none in Europe. By using the same methodology in different regions, CDC investigators have been able to identify common themes, which may help inform global research and capacity building needs.

Sophisticated metrics for cost-benefit analyses

OHZDP is a strong advocacy tool, but allocation of adequate resources to the prediction, prevention and control of zoonoses within a world of competing interests also requires robust economic data on the cost-effectiveness or cost-benefit of alternative courses of action. Economic evaluation of One Health Interventions within the surveillance, control and response to zoonoses is crucial to developing a robust 'Business Case' for One Health, including important discussions regarding cost-sharing between human and animal and public and private sectors. These evaluations require consistent metrics by which the burden of diseases can be measured in both the human and non-human populations. Whilst metrics are available to measure human health outcomes, such as the disability adjusted life year (DALY) developed for the global burden of diseases study, quantifying the impacts of disease within differing hosts requires more sophisticated metrics where impacts from both sectors can be measured in an equivalent way. Two solutions to this problem have been proposed to date. The Zoonoses-DALY (zDALY) transforms economic losses in livestock into an 'animal life equivalent' based upon the time taken to recoup that loss in the specific geographic context. An alternative approach is the transformation of human health burden into economic terms using the value of statistical life (VSL).

While substantial progress has been made to quantify the impacts of some zoonoses and foodborne illnesses, considerable gaps remain, particularly regarding the burden of disease in animal populations, and the impact of AMR on both humans and animals. Undertaking the robust, systematic collection, analysis and dissemination of this data is the founding mission of the Global Burden of Animal Diseases study (GBADs). This ambitious study will be undertaken by a large collaboration of academic partners with the support of the Bill and Melinda Gates Foundation, UK's Foreign, Commonwealth & Development Office (FCDO), Australian Centre for International Agricultural Research (ACIAR), the equine welfare NGO Brooke, World Organization for Animal Health (OIE) and the UN Food & Agriculture Organization (FAO).

It is important, however, that further dimensions are integrated into our frameworks, including the social dimensions of human and animal disease and capturing environmental impacts. A full appreciation of the wider impacts of zoonoses is likely needed for the large-scale transformation of food, health and animal health systems which are required to move into a more sustainable, safe and food-secure world fit for habitation by both nine million people and the wide diversity of non-human life which our planet sustains.

Lian Thomas is a veterinarian and epidemiologist working at the Institute of Infection, Veterinary and Ecological Sciences, University of Liverpool, United Kingdom and the International Livestock Research Institute (ILRI). She is currently theme lead for Neglected Zoonoses in OHRECA and is a Soulsby Foundation One Health Fellow.
Grace Patterson is a microbiologist and epidemiologist studying food systems and health at the University of Liverpool's Centre of Excellence for Sustainable Food Systems.
Lucy Coyne is a veterinarian and epidemiologist with research interests in antimicrobial resistance and policy. She is currently working in government policy and is an honorary postdoctoral research associate at the Institute for Infection, Veterinary and Ecological Sciences, University of Liverpool.
Jonathan Rushton is a biologist and economist working at the Institute of Infection, Veterinary and Ecological Sciences, University of Liverpool. He leads a University Centre of Excellence for Sustainable Food Systems and the Global Burden of Animal Diseases programme.
Contact: lianthomas1@gmail.com

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Outbreaks of epidemics tend to be a greater threat to people in remote regions. But in this respect too, COVID-19 appears to be different.

Photo: Jörg Böthling

COVID-19 research – what really matters

With over 59,181 research articles already cited by the literature hub NCBI LittCovid at the time of writing, the task of providing all of the "latest" findings in COVID-19 research is impractical. Misinformation is also rife, and contradictory results and discussions from different science perspectives are misused on media and are undermining the value of science in the eye of the general public, who seek certainties. Keeping this in mind, this short article is a brief review of what research the author, with an eye on SARS-CoV-2 virus and the disease, believes to be pertinent to rural development in a post-COVID-19 world.

By Richard Kock

The COVID-19 paradox is fascinating and relevant to development strategies in modern times. How I define this paradox is as follows:

There is an apparent reversal with COVID-19 of the usual disease expression-impact paradigm globally between rich and poor countries, with fewer negative outcomes from the pandemic reported in so-called less-developed low-income nations (e.g. most African nations) compared to more-developed high-income nations, such as the UK and the USA, with some notable exceptions like New Zealand, which may relate more to geography and politics than to any other factor.

The common explanation for this paradox is that less developed settings are unable to report adequately, but this "belief", or perhaps "prejudice", is confounded by time and the trend data, which is not influenced by the reporting effort (see Figures). What seems to be at work in poorer less-developed countries is a slower and lower overall infection rate, case incidence rate, case fatality rate and overall mortality. This is best exemplified by Africa, which has the highest proportion of low-income countries of any continent.

Teasing out the risk factors for emergence, spread and impact is complex, but some obvious differences and correlates between countries can be gleaned from examining factors like the degree of development, air travel indices, population distribution and networking, urban-rural proportions, geographies, socio-political and agro-ecological systems, age structures and specific co-morbidities such as obesity and many other parameters over the period of the pandemic. What is clear is that the virus has caused havoc in countries with higher Global Health Security indices and high expenditure per capita on health. There is also a reversal of fortunes, with population benefit being more rural, compared to urban and suburban settings, both in terms of mental health and risk of COVID-19 disease. Normally, health services are more accessible and advanced in urban settings and there is a gradient of health risks in face of epidemic diseases, rising into the remoter, poorly serviced rural locations in a country.

COVID-19 – the "treatment": lockdown

The general response to the epidemic was based on a "policy" called "lockdown" which amounted to an almost gut reaction by Public Health and politicians to the rapid emergence and inability to treat or prevent the infection and its clinical impacts. The objective was to lower the rate of infection and prevent an unmanageable crisis particularly in the health delivery systems, whilst the large conventional health science community caught up with understanding the pathogenesis and epidemiology, modelling scenarios, finding appropriate treatments of cases and developing vaccines. The modellers and vaccinators have been the most vocal and publicised elements in Public Health communication. Benefits of lockdown were more evident in highly organised societies, based on rapid suppression of infection rates and alleviation of pressure on intensive care units, and enabled by a higher level of community adherence to political dictat and some belief in Public Health messaging, and, perhaps most importantly, sufficient wealth to buffer socioeconomic costs. In contrast, in this respect,

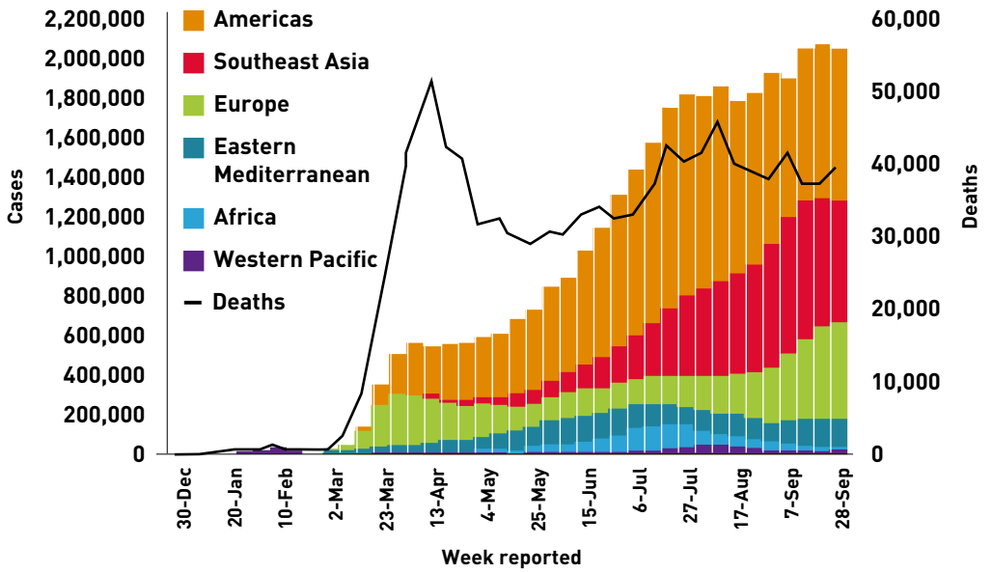
less developed countries have suffered greatly, more from the unpredictable socioeconomic effects and health challenges generated by this policy than from any other factor. It is still early days for a retrospective analysis of impacts from the disease and different responses across the world and for identifying lessons learned.

COVID-19: where did it come from and why?

The speculation on origins of COVID-19 follows a similar pattern to SARS, which occurred in 2003, in a similar region of the world. Despite a considerable research effort, we still do not have a known animal reservoir for SARS, and nothing is proven yet for SARS-CoV-2. SARS burned out with only a few hundred deaths and this took some focus away from further prevention of this clearly dangerous situation in Southeast Asia with respect to emerging coronavirus infections. The genetic origins of both these viruses is likely in the animal kingdom and bats are given the greatest prominence through researchers having isolated many SARS-like viruses, especially from horseshoe bats, but still no actual virus source has been found. In SARS, proven infection of farmed wildlife species used for fur or the food industry created some speculation on these species as a proximate source but this was not proven other than for infection in one or two cases. No further zoonosis with SARS has been reported, which suggests that there was no reservoir species.

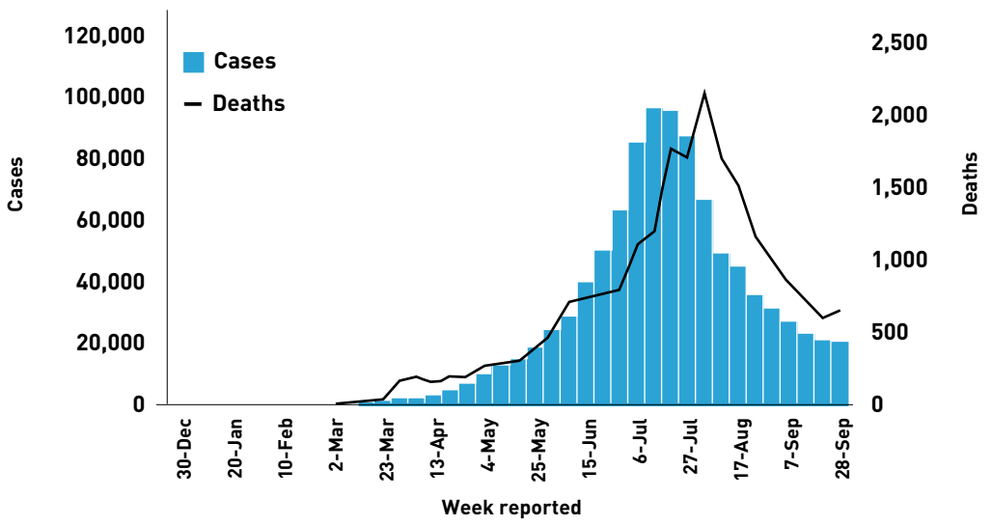
Anthropozoonosis, the transmission of a virus from people to animals, is possible for both SARS and SARS CoV-2, and many species have been shown susceptible, but this is not proof of established zoonosis. The term zoonosis is often used to explain COVID-19, but there is actually no evidence to confirm an ongoing zoonosis. It is clearly a human disease, and the origin may simply be a unique spill-over event. The association of Wuhan Wet Market with animals may be spurious, as humans could equally have brought the virus into the market and spread it on surfaces. No animal was found with the virus. To have two viruses of a similar nature enter the human population and establish epidemics is probably beyond chance. There must be some specific drivers for this happening, and presumably, these remain in place. Any aspect of human behaviour, industry or practice creating risk of coronavirus emergence must be discovered and addressed for the sake of future human health and the economy, given the massive global impact of COVID-19.

Number of COVID-19 cases reported weekly by WHO Region, and global deaths, 30 December 2019 through 04 October 2020



Source: WHO

Number of COVID-19 cases and deaths reported weekly by WHO African Region, as of 4 October 2020



Source: WHO

In the context of rural development and disease, the risks of urbanisation need to be taken more into account in the future, as must the possible role of food systems in the emergence of such pathogens. If a wildlife species source is proven, the role of rural populations in exploiting wildlife for farming or trade and consumption will need to be examined very critically. It is notable that wildlife farming was promoted as a poverty reduction policy in China in the past two decades, which is coincident with the emergence of coronaviruses, and this was a similar pattern for the emergence of the "Bird flu" zoonotic diseases which occurred after a rapid growth in the duck and poultry sector in China over a similar timeframe.

Richard Kock is a Professor at the Royal Veterinary College, University of London, United Kingdom.
Contact: rkock@rvc.ac.uk

References: **www.rural21.com**

Adopting the One Health approach in international practice

Taking H5N1 as an example, our author describes how global collaboration in combating this disease turned into a One Health approach which has since gained significance reaching way beyond tackling zoonotic diseases.

By Katinka de Balogh

In late 2003, poultry farms in the Central and Northern Regions of Thailand experienced large-scale die-off. Highly pathogenic avian influenza (HPAI) virus of the H5N1 subtype, also called bird flu, was confirmed in poultry on the 23rd January 2004, the same day that the Thai Ministry of Public Health (MOPH) announced two laboratory-confirmed cases of H5N1 virus in children, who later died of the disease. In the meantime, other countries in East and Southeast Asia also reported infections in poultry and humans. Scientists and politicians feared that this could be the start of a global pandemic, similar to the Spanish flu caused by H1N1 influenza, killing an estimated 20-50 million humans globally between 1918 and 1920. Parts of the world started stocking up on Oseltamivir (commercially known as Tamiflu), an antiviral medication used to treat and prevent influenza A and influenza B (flu), including H5N1. In 2005, in response to the further spreading epidemic, various governments stockpiled quantities of Oseltamivir in preparation for a possible pandemic, leading to overall shortages of the drug.

At the time, the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE) called countries to address "bird flu" at its source in animals to avoid its spread to humans. As H5N1 occurs naturally in wild waterfowl, it can spread easily to domestic poultry, especially in rice-farming areas where domesticated ducks are kept on post-harvest rice paddy fields. These rice paddy fields are equally attractive to wild birds and are therefore viral transmission points between wild and domesticated birds. The understanding of the ecology in which the virus transmits was key for the development of viable disease control interventions. Furthermore, the identification of human risk behaviour linked to persons handling infected poultry (with fortunately, no sustained human-to-human transmission) provided the basis for risk communication messages preventing the spread from infected poultry to farmers, traders or consumers.

This example illustrates the need for different sectors such as Ministries of Health, Agriculture and the Environment, as well as various disciplines ranging from human and animal health professionals, wildlife ecologists, epidemiologists, communication experts and behavioural scientists to come together under a One Health umbrella to address H5N1. The aim is to identify the emergence of a disease at an early stage through good surveillance and reporting, the collection and shipment of animal samples, reliable laboratory diagnostics and triggering contingency plans put in place and practised as part of an emergency preparedness and response concept.

From the first global strategic framework to national task forces

In January 2006, a pledging Conference in Beijing, China brought together officials from half the world's nations to come up with the finances for a three-year action plan to address H5N1 epidemic. At the time, the disease had killed nearly 80 people, mostly in Asia, and had spread to the Middle East and into Europe, with Turkey confirming its fourth human fatality. A United Nations system coordinator for avian and human influenza was appointed, and Ministers of Health and Agriculture would meet on a regular basis to further assess global progress in controlling Highly Pathogenic Avian Influenza (caused by H5N1 virus) and propose actions to further reduce and potentially eliminate the disease. In October 2008, four specialised agencies, FAO, OIE, the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), together with the World Bank and the UN System Influenza Coordinator (UNSIC), developed "Contributing to One World, One Health (OHOW)", a Strategic Framework for Reducing Risks of Infectious Diseases at the Animal–Human–Ecosystems Interface. The document was launched in 2008 during the Sharm-El-Sheikh International Ministerial Conference on Avian and Pandemic Influenza (IMCAPI) event in Egypt. The objective of the Framework was to diminish the risk and

Children are at particular risk of catching rabies from dogs.

Photo: Jörg Böthling

minimise the global impact of epidemics and pandemics due to emerging infectious diseases by enhancing disease intelligence, surveillance and emergency response systems at national, regional and international levels, and by supporting them through strong and stable public and animal health services and effective national communication strategies. The OWOH approach (which later became just One Health) references the "Manhattan Principles", which were developed in 2004 during a symposium organised by the Wildlife Conservation Society (WCS) and hosted by The Rockefeller University and recognise the intimate linkages among the human, animal and ecosystem health domains.

Since then, One Health has evolved. There have been seven International Ministerial Conferences on Avian and Pandemic Influenza (IMCAPI), bringing together the Ministers of Health and Agriculture to discuss H5N1 and other emerging threats. At country levels, inter-ministerial committees and task forces were established to focus on avian influenza in first instance, but gradually they also transitioned to address other zoonotic diseases.

Widening the scope – One Health not only for emerging zoonotic diseases

Beside the importance of emerging zoonotic diseases in 2005, the Joint WHO/DFID-AHP (animal health programme) Meeting on neglected zoonotic diseases mentions the importance of One Health as a way of dealing with various health problems in both people, their livestock and other domestic and wild animals they depend on. Gradually, rabies emerged as the One Health model disease that would require collaboration and communication between animal and human health. In Bali, Indonesia, after the introduction of rabies in late 2008, with the province's authorities, FAO developed "Integrated Bite Case Management (IBCM)". It entailed that after somebody had reported a dog bite to a health centre, the animal health side would be informed and investigations by both sectors would be coordinated to see if there were further animals suspected of having rabies and if further persons had been exposed to rabid animals. IBCM is a good example how One Health translates into action.

One Health was proposed as a concept to foster interdisciplinary collaboration and was adopted with great enthusiasm, especially by the veterinary profession and by the international agencies charged with control of zoonoses, such as FAO and OIE. World-wide, the veterinary profession promoted the concept of One Health to address, besides zoonotic diseases, issues such as food safety, food security, antimicrobial resistance, climate change and the human-animal bond. Within the human health sectors it was also mainly the veterinarians working in public health who embraced One Health. Nevertheless, in 2010 FAO, OIE and WHO agreed on a Tripartite Concept Note, "The FAO–OIE–WHO Collaboration – Sharing responsibilities and coordinating global activities to address health risks at the animal–human–ecosystems interfaces". This Tripartite partnership made a commitment to jointly address health risks at the interface, recognising the need to establish an environment in which ministers representing the various sectors within countries can voice their expectations and come to a consensus on future activities, particularly collaborative ones. Ensuring a high-level technical perspective on the issues was seen by the Tripartite and global partners "to be critical to formulating the rationale and arguments that would effectively engage ministers".

In November 2011, a High Level Technical Meeting (HLTM) to address health risks at the human-animal-ecosystems interface was organised by the Tripartite with UNSIC and Mexico's Ministries of Health, Agriculture and Environment. The meeting in Mexico provided a venue for stakeholders from the national health, agriculture and environmental sectors and from technical, regional, and donor organisations to contribute their perspectives and expertise. Participants from the different sectors considered, and came to agreement on, cross-sectoral technical and policy approaches to address the mutual priorities such as zoonotic influenza, rabies and antimicrobial resistance (AMR). During the meeting, the key principles for cross-sectoral coordination, collaboration and communication were developed (see Box on next page), as were the next steps for moving forward to implement zoonotic influenza, rabies and AMR as three Tripartite priority issues under One Health.

Antimicrobial resistance: engaging the agriculture and environment sectors

Antimicrobial resistance is a complex, multifaceted problem that threatens human and animal health, the global economy, and national and global security. Beside the public health and veterinary sectors, addressing antimicrobial resistance requires the engagement of the wider agriculture and environment sectors as part of One Health. After adoption of various resolutions by the highest fora of the Tripartite in 2015, at the United Nations General Assembly in 2016, global leaders recognised AMR as one of the biggest threats to global health, endangering other major priorities, including human development. Heads of State and Heads of Delegations addressed the seriousness of the situation and agreed on sustainable, multisectoral approaches to tackling antimicrobial resistance. Countries committed to developing integrated AMR National Action Plans (NAPs). In 2017, the Tripartite launched a commitment, providing multi-sectoral, collaborative leadership in addressing health challenges including AMR.

With increasing livestock and aquaculture production, especially often, the use of cheap antibiotics replaced the adoption of good hygienic practices and overall biosecurity. Even in the crop sector, antibiotics are used, albeit certainly to a lesser extent compared to in animal production, to combat plant bacterial diseases

TABLE-TOP SIMULATION EXERCISES FOR ZOONOTIC DISEASES

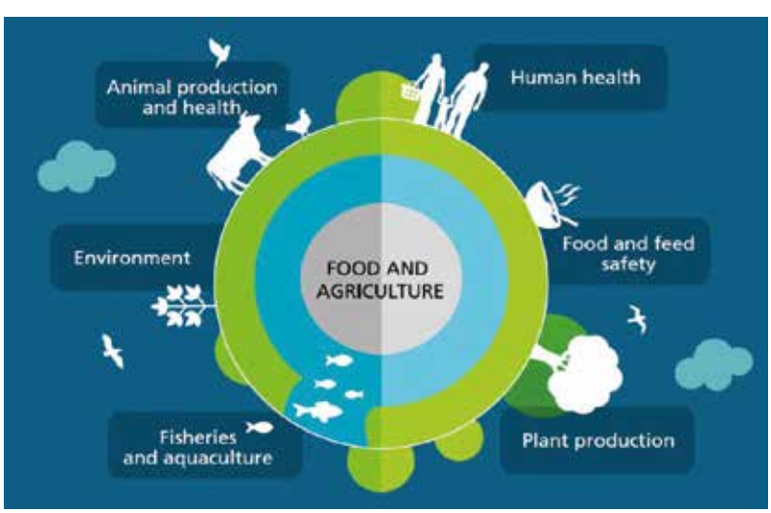
National table-top simulation exercises have been developed by the Food and Agriculture Organization of the United Nations (FAO) and its partners to strengthen in-country capacities for emergency preparedness and response for zoonotic diseases at the human-animal-ecosystems interface. The two-day, room-based simulation exercises bring together professionals of different sectors involved in addressing emerging disease outbreaks in human and animal populations (e.g. Ministry of Agriculture and Ministry of Health professionals, veterinary and public health epidemiologists, laboratory diagnosticians, private service providers, communication experts, environment and wildlife services, civil defence, farmers' associations). The simulation is based on a scenario describing a fictitious outbreak, from its suspicion to its control, and participants address questions covering the different activities which would be carried out in response to the different phases of the evolving disease situation. Through the simulation exercise, national preparedness and capabilities in controlling the emergence of a zoonotic disease are assessed. The gaps identified are used to enhance a country's contingency plans and to develop a national action plan to improve its preparedness and response capacity for the prevention and control of zoonotic threats.

Rice paddy fields are viral transmission points between wild and domestic birds. Photo: Adobe Stock

such as fireblight of apples, citrus canker and the use of streptomycin to protect rice crops. The use of antibiotics on crops is generally denominated as "pesticides". Therefore, besides the animal production sector, it is also important to involve the crop sector and the wider agriculture sector as part of addressing antimicrobial resistance in a One Health manner. In addition, so far, the environmental sector has been the last one coming to the table in the discussions on tackling AMR. The problem of run-off from all types of farms where antimicrobials are used for crops, livestock and aquaculture and effluents from slaughterhouses, hospitals and antimicrobial-producing industries as well as from waste dumping sites clearly requires close collaboration with those dealing with the environment. Especially in the Asia-Pacific region, the FAO/OIE/WHO Tripartite has been working intensively with the United Nations Environment Programme (UNEP) on AMR. For the World Antibiotic Awareness Week in 2019, the video "Don't let antimicrobials take control: Be responsible when using antibiotics!" was collaboratively produced by FAO, OIE, WHO and UNEP to raise awareness on the risks of AMR, including the drivers of AMR spread between animal-human-food and the environment.

From farm to fork to food systems: why we need a holistic approach

The FAO/WHO Codex Alimentarius is a joint Food Standards Programme which held its first meeting in 1963 and aims at protecting consumer health and promoting fair practices in food trade by linking agriculture and health sectors. While initially a linear correlation from farm to fork as a way to strengthen food chains and enhance food safety, nowadays, we tend to talk about food systems in view of the complexities and interconnections from production to consumption of our food. Although One Health was in first instance conceived to address infectious diseases, the multidisciplinary and multi-sectoral approach has also made it valuable focusing on residues from various sources including pesticides, heavy metals and antimicrobials in feed, food, agriculture as well as the environment.



While currently the COVID-19 pandemic is ravaging, we do not know what is yet to come. Lessons learned from the current pandemic include the unprecedented human and socio-economic global impacts of an emerging zoonotic disease and the need to address drivers of disease emergence and spillover. More than ever, it is important to invest in coordinated mechanisms, policies and capacities at national, regional and global levels to prevent, prepare and respond to health threats at animal-human-environment interfaces through the application of One Health.

KEY ELEMENTS OF EFFECTIVE CROSS-SECTORAL COLLABORATION*

Key supporting elements

1. Political will and high-level commitment
2. Trust
3. Common objectives and priorities
4. Shared benefits
5. Strong governance structures, aligned legal frameworks and recognition of existing international standards
6. Adequate and equitably distributed resources
7. Identification and involvement of all relevant partners
8. Coordinated planning of activities
9. Guidance on implementation of cross-sectoral collaborations
10. Capacity development
11. Strong and effective health systems within the individual sectors

Key operational elements

A. Joint cross-sectoral coordination mechanisms
B. Routine communication
C. Joint simulation exercises
D. Data sharing
E. Joint risk assessment
F. Active cooperation on disease control programmes

* Developed during the High-Level Technical Meeting to Address Health Risks at the Human-Animal Ecosystems Interfaces, Mexico City, Mexico 15-17 November 2011.

Katinka de Balogh is a veterinarian with a doctorate in tropical parasitology and a specialisation in Veterinary Public Health. She has been based in various countries in Africa, Asia and Europe and has worked for the Netherlands International Development Cooperation, World Health Organization and the Food and Agriculture Organization of the United Nations.
Contact: katinka027@gmail.com

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From research to implementation strategies – One Health Capacity Building

Fuelled by zoonotic disease outbreaks of avian influenza and swine influenza in the early 2000's, the epidemics of Ebola and Zika in the 2010's, and the most recent pandemic outbreak of COVID-19, the importance of implementing One Health has become increasingly prioritised. But capacity building comes before implementation. Who researches the topic, who runs training programmes, and which initiatives and institutions back knowledge transfer?

By Timo Falkenberg

One Health has its roots in veterinary medicine, so it is unsurprising that traditional One Health research should focus on zoonotic diseases, which are transmittable between humans and animals. While interdisciplinary collaboration has been at the heart of One Health since its inception, the involved disciplines were initially limited to veterinary and human medicine along with their allied public health disciplines. The original term 'One Medicine' indicated that both human and veterinary medicine share a substantial body of knowledge, including physiology and pathology. One Medicine, therefore, called for convergence of medical education and knowledge integration of medical research. Essentially assessing the biological similarities and difference between animals and humans to gain understanding about transmission, emergence and treatment of communicable and non-communicable diseases, research following this traditional approach is primarily in the sphere of comparative medicine. Vaccine development, cancer treatment as well as the use of pig heart valves to treat human cardiovascular disease are among the medical advances evolving from research in comparative medicine. With the formulation of the "12 Manhattan Principles" at the conference of the Wildlife Conservation Society in 2004, the rather clinical One Medicine evolved towards One Health by placing a strong emphasis on the underlying ecological and social factors that determine the health of both animals and humans. Inevitably, this expansion of the approach extended the range of disciplines involved in One Health research, which nonetheless remains dominated by the medical disciplines with a consistent focus on controlling zoonotic diseases via awareness building, vaccination, monitoring, outbreak detection and treatment.

Scientists of the International Livestock Research Institute.

Photo: ILRI/ Paul Karaimu

Driving knowledge-building – a look at the global institutional landscape

In the late 2000's, the institutionalisation of One Health was initiated at global level. In 2007, the One Health Initiative was formed with the sole purpose of promoting One Health. In 2009, the One Health Commission was founded in Washington D.C. with the main mission of raising awareness of One Health among the general public and policy-makers and educating a future One Health workforce. These organisations understood early on that One Health research requires collaboration between disciplines which do not traditionally work together as well as researchers with transdisciplinary skills enabling such collaborative research. Another important body of the One Health landscape is the One Health Platform, a Scientific Reference Network linking scientists of various disciplines and industrial and governmental stakeholders to drive One Health research and integrate knowledge. The One Health Platform has initiated "One Health Day", celebrated by decentralised events world-wide on the 3rd November to raise awareness of and spread knowledge on One Health. Additionally, it organises the "One Health Congress" and the "One Health Forum", bringing together interdisciplinary scientists, policy-makers and the private sector to share research results and disseminate evidence-based recommendations.

A great acceleration of One Health research was noted after its endorsement by international organisations. The "Tripartite Agreement" between the World Health Organization (WHO), the World Organization for Animal Health (OIE) and the Food and Agriculture Organization (FAO) was published in 2010. The Agreement set out that these major organisations would collaborate to tackle the complex health challenges arising at the human-animal-environment nexus, as these cannot be solved by any one sector in isolation. Already in 2009, the U.S. Center for Disease Control (CDC) established its One Health Office that is focused on monitoring and controlling emerging and zoonotic infectious diseases by building partnerships across the human, animal and environmental sectors. Additionally, a key priority of the CDC One Health Office is to help countries around the globe to implement One Health. The Zoonotic Disease Prioritization Tool, developed by the CDC, is viewed as an important first

step towards enabling the implementation of One Health at national (or regional) levels, as any form of collaboration initially requires a consensus about what challenges need to be jointly tackled.

Focusing on antimicrobial resistance and zoonotic diseases

One Health has become a priority on the global policy agenda, primarily due to the human health risks exhibited by emerging and zoonotic diseases as well as antimicrobial resistance (AMR). These topics are consequently also the topics that are being prioritised for One Health research. In the sphere of AMR, the scientific evidence is quite clear and alarming. Pathogens are getting increasingly resistant, and such resistant pathogens or resistance genes are found in environmental samples across the globe. From a purely scientific standpoint the solutions to the growing problem of AMR are quite simple and straightforward. The usage of antimicrobials needs to be significantly reduced in human and veterinary medicine as well as in agriculture. However, from an interdisciplinary perspective, the issue is more complex. For example, banning antibiotics for livestock has impacts on farmers' livelihoods and animal welfare. Therefore, regulation is required rather than outright bans. Reducing antibiotic use in human populations calls for significant behaviour change among patients and prescribers, for which education and health promotion campaigns are needed. Also, low-income populations overuse antibiotics more frequently than high-income populations, while at the same time, the increasing accessibility to these drugs in low-income settings is viewed as a huge success of the health system.

In the sphere of emerging and zoonotic diseases, the evidence base is a lot more volatile. While in principle, the mechanisms of zoonotic spill-over are understood, it is highly difficult to predict which pathogen will spill over where and when, and it is even more difficult to predict the disease burden of such pathogens. Consequently, there is a general consensus among One Health scientists that integrated disease monitoring is required. Disease surveillance data of wildlife, livestock and humans need to be integrated into a common platform to allow integrated analysis and subsequent prediction of spill-over hotspots and targeted One Health action.

The knowledge gaps in One Health are increasingly moving out of the medical disciplines and into political science, agricultural science, sociology, economics, data science and geography. A primary question that needs to be addressed is how One Health can be implemented, and what governance structures, institutions and funding mechanisms are required. This is very closely linked to scientifically proving the efficiency and effectiveness of One Health to address the complex health challenges. While it is commonly claimed that One Health interventions are more cost-effective compared to multiple sectoral interventions, very few studies exist which actually provide empirical evidence for this claim. One Health also requires changes in behaviour at both community and economic and political level. To address these knowledge gaps, it is necessary to train and educate an interdisciplinary workforce, looking beyond the classical medical and health science disciplines.

One Health education in the Global North

More and more One Health courses have been introduced world-wide since the high-level endorsement of the WHO, OIE and FAO. In the USA, a number of universities are offering degree courses in One Health. The School of Public Health of the University of Washington, for example, has established the Center for One Health Research, while the University of Arizona and the Midwestern University are offering Master degrees in One Health. Penn State, Texas A&M, Berry College and Ferrum College are running an undergraduate Minor course in One Health. In Europe, the number of such degree programmes is also growing. The London School of Hygiene and Tropical Medicine is offering a Master course on One Health in collaboration with the Royal Veterinary College. The Universities of Liverpool, Edinburgh and Glasgow are running Masters level One Health degree courses. Inside the EU, the University of Utrecht offers a MSc One Health within the Biomedical Science discipline. Université de Tours, Universitat Autònoma de Barcelona and Hannover Medical School are running a Masters programme on Infectious Diseases and One Health, with students studying one semester each in France, Spain and Germany. In cooperation with the Swiss Tropical and Public Health Institute, the University of Basel is offering free online courses on One Health.

At doctoral level, two programmes are being offered in Europe, among them the EU-funded One Health European Joint Programme,

THE 'ONE HEALTH AND URBAN TRANSFORMATION' GRADUATE SCHOOL

The NRW Forschungskolleg 'One Health and urban transformation' is a graduate school funded by the state of North Rhine-Westphalia's Ministry of Culture and Science and is jointly operated by the University Bonn, the University of Applied Science Bonn Rhein-Sieg and the United Nations University – Institute for Environment and Human Security. At the graduate school, 13 doctoral students conduct their research on various One Health topics at the four study locations of Accra (Ghana), Ahmedabad (India), Ruhr Metropolis (Germany) and São Paulo (Brazil). They have diverse academic backgrounds, including public health, geography, biology, mathematics, soil science, sociology and nutritional science. The on-going research projects were developed transdisciplinarily through close collaboration with stakeholders from politics, academia, the private sector and civil society. As a result, interdisciplinary, action-oriented research projects were conducted to holistically examine health challenges of the One Health nexus in the context of urban transformation processes (see Box on next page). A second batch of doctoral students will begin the structured programme in January 2021.

The first batch of the graduate school doctoral students. Photo: Timo Falkenberg

IDENTIFYING BARRIERS TO ONE HEALTH IMPLEMENTATION IN INDIA

Doctoral student Yasobant Sandul has conducted his research in the context of Ahmedabad, India, aiming to operationalise One Health at municipal level. Sandul examined the current degree of collaboration between human, veterinary and environmental sectors and assessed the barriers to One Health implementation. Understanding the degree of collaboration at the administrative/ policy, provider and community levels serves as an important first step in developing One Health implementation strategies. The extensive research resulted in a five-step process to assess and advance the implementation and operationalisation of One Health, comprising the prioritisation of goals, identification of actors, assessment of current network cohesion, establishment of decision-making processes and identification of enablers and barriers.

In the context of the current research, the focus was on controlling zoonotic diseases, therefore, the One Health Zoonotic Disease Prioritization (OHZDP) tool of the CDC was utilised. The intersectoral stakeholder group prioritised rabies, brucellosis, influenza and Crimean-Congo haemorrhagic fever for collaborative One Health actions. However, the research also found overall low commitment to intersectoral collaboration during non-outbreak periods, which constrains sustainable One Health operationalisation.

More information: www.zef.de/onehealth.html

Cows sefting through rubbish for food in Ahmedabad, India. Photo: Timo Falkenberg

which has 37 partner institutions and runs 16 doctoral projects. The only structured programme is the One Health and urban transformation graduate school run at the University of Bonn's Center for Development Research in cooperation with the University of Applied Science Bonn Rhein Sieg and the United Nations University (see Box on page 18).

One Health capacity building in the Global South

As mentioned above, the CDC is contributing to the implementation of One Health by advising national governments and developing tools for prioritisation. Various international organisations, including the World Bank, WHO and FAO, are facilitating the development of intersectoral collaboration for One Health implementation in Africa and Asia. Governmental and private donors, such as Germany's Federal Ministry for Economic Cooperation and Development (BMZ), USAID, the Rockefeller Foundation and the Wellcome Trust, are financing One Health capacity building, including training programmes for the health workforce and expansion of transdisciplinary competences. Great achievements have already been attained, as reflected by the Afrique One-ASPIRE Alliance, which is a consortium of research institutions in Chad, Ivory Coast, Ghana, Tanzania, Uganda and Senegal, or the Africa One Health University Network (AFROHUN), which is a network of 16 universities in Cameroon, DR Congo, Ethiopia, Kenya, Uganda, Rwanda, Tanzania and Senegal, having trained 4,500 students since its inauguration in 2010. At national level, various initiatives have come to fruition which drive the application of One Health on the African continent. Examples include the Kenya Zoonotic Disease Unit, the Cameroon Zoonosis Program, the Uganda Zoonotic Disease Coordination Office and the Ghana One Health Technical Working Group.

In Asia, commitment to One Health is also high. This is exemplified by the One Health Network South Asia and the One Health Network South-East Asia. One Health Hubs have been established in Bangladesh, Pakistan, India, Bhutan, Nepal and Sri Lanka, serving as national coordination centres aiming to expand collaboration between governmental sectors to control zoonotic and emerging diseases. Bangladesh has developed a National One Health Strategic Framework and Action Plan, leading to the establishment of the One Health Secretariat. The Southeast Asia One Health University Network (SEAOHUN) is undertaking the One Health Workforce project with USAID, FAO, ILRI and government institution support. This project trains university faculty members to educate the future One Health workforce.

From concept to policy to practice

One Health is moving from concept to practice, focusing on the sphere of zoonotic and emerging diseases. Capacity building programmes primarily focus on developing cooperation between human and veterinary health sectors for monitoring, detection and control of zoonotic outbreaks and training the according workforce. While it is essential to build capacity for controlling zoonotic and emerging diseases, more disciplines and sectors need to be involved in One Health, where research is starting to move beyond the classical One Health topics, going beyond reactively identifying and controlling disease threats, but aiming to understand and tackle the root causes of the increasing zoonotic spill-over risks by looking into land-use changes, environmental degradation, agricultural practices, community behaviour and animal welfare. One Health requires interdisciplinary expertise and political commitment to move from concept to policy and from policy to practice. Capacity building and educational programmes are growing globally, creating the One Health workforce urgently required to effectively control and prevent the health challenges at the human-animal-environment interface.

Timo Falkenberg is a senior researcher at the Center for Development Research (ZEF), Bonn, Germany and coordinator of the Forschungskolleg One Health and Urban Transformation. He is cooperating with the GeoHealth Center of the University Hospital Bonn (UKB) and is an adjunct faculty member at the Indian Institute of Public Health Gandhinagar (IIPH-G).
Contact: falkenberg@uni-bonn.de

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An interdisciplinary centre of excellence for pastoralists in the Horn of Africa

The specific needs of nomadic pastoralist communities are often not considered in public services. This is also the case in the health sector. In Ethiopia, Swiss Development Cooperation is supporting the establishment of a regional One Health centre of excellence. Four Ethiopian ministries are also involved.

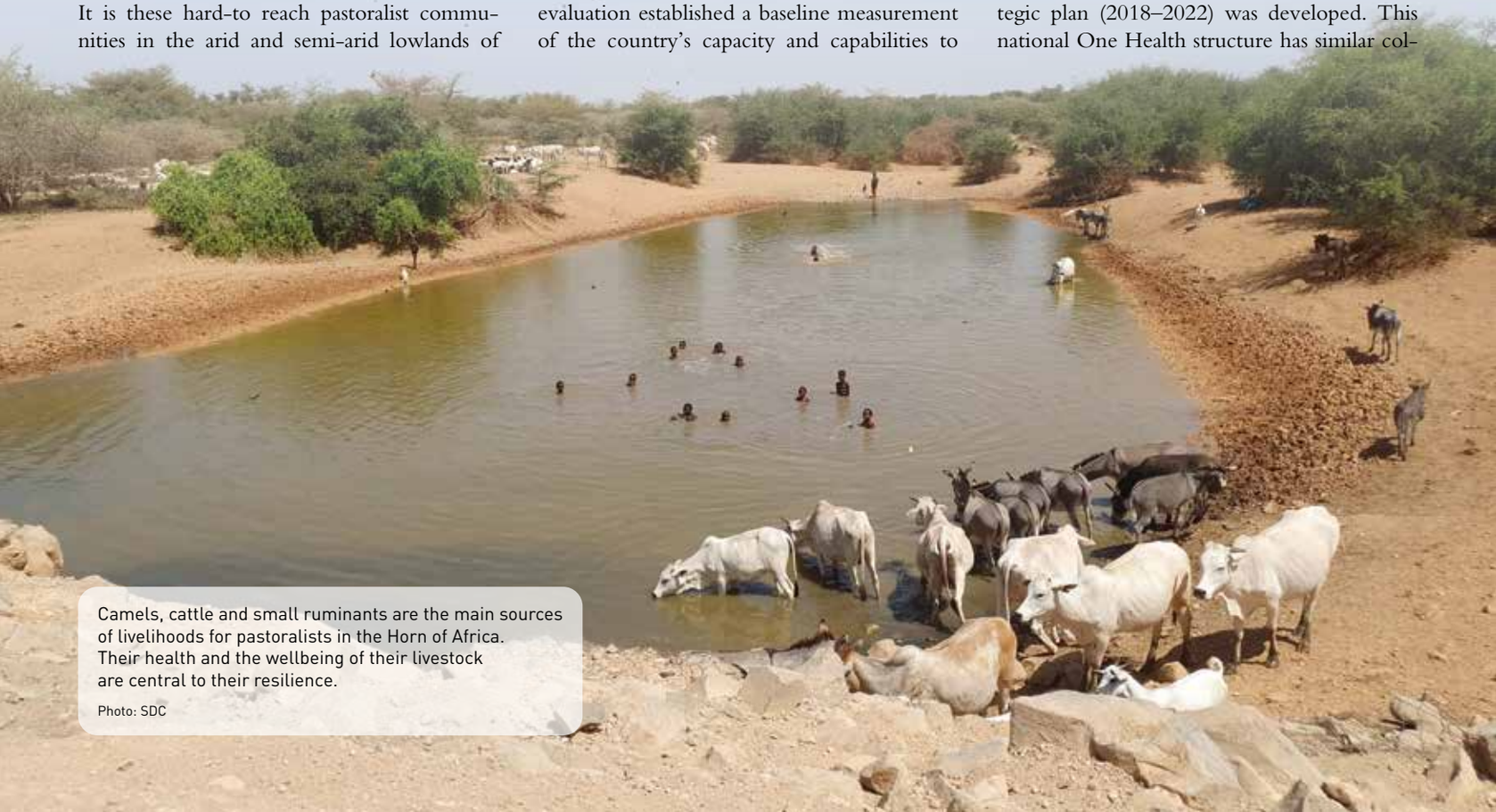
By Jakob Zinsstag, Lensse Gobu, Rea Tschopp and Mohammed Ibrahim Abdikadir

Over 30 million pastoralists in Ethiopia, Somalia and Kenya are affected by inadequate access to essential healthcare and a poorly developed veterinary service for their livestock. Pastoralist communities are subjected to a variety of health problems, some of which stem from the population's close interaction with and dependence on livestock (e.g. Rift Valley Fever, Q-fever, rabies and milk-borne diseases) and the rest being largely preventable communicable diseases and nutritional disorders. Both the public health and animal healthcare systems in the region are faced with multiple challenges. These include limited access to health services, weak coordination among providers, poorly equipped and understaffed primary healthcare units, and shortage of drugs and medical supplies.

Integrated health systems for pastoralist communities

It is these hard-to reach pastoralist communities in the arid and semi-arid lowlands of the region living in Somalia, Northern Kenya, South and South-Eastern Ethiopia which are the focus of SDC's (Swiss Agency for Development and Cooperation) strategy and its health programme in the Horn of Africa. One Health is one of the four thematic pillars of the health sector, alongside maternal and child health, private sector engagement and sexual and gender-based violence. The goal of the health programme is to improve the access of the most vulnerable population (poor pastoralists, internally displaced people [IDPs], urban poor, women and children) to affordable high-quality health care. One of the initiatives in the context of the thematic pillar One Health is the establishment of an interdisciplinary centre of excellence at Ethiopian Jigjiga University.

In 2016, the Ethiopian government invited international experts for a Joint External Evaluation to assess its health system. This evaluation established a baseline measurement of the country's capacity and capabilities to prevent, detect and rapidly respond to public health threats. In connection to this, the National One Health Steering Committee (NOHSC) and the Technical Working Group (TWG) were formally established, comprising four core governmental ministries (the Ministries of Health and Agriculture, the Ethiopian Wildlife Conservation Authority [which is under the Ministry of Culture and Tourism] and the Ministry of Environment, Forest and Climate Change) and other relevant partners within the human, animal and environmental health mandates. These development partners, such as the UN's Food and Agriculture and World Health Organizations, USAID, universities and NGOs, support the activities of the NOHSC. This has allowed a closer coordination between the different partners. To accelerate the multi-sectoral collaboration and reduce the risks of health threats at the human-animal-environment interface in the country, a five-year national One Health strategic plan (2018–2022) was developed. This national One Health structure has similar col-



Camels, cattle and small ruminants are the main sources of livelihoods for pastoralists in the Horn of Africa. Their health and the wellbeing of their livestock are central to their resilience.

Photo: SDC

laborative structures at the level of the regional states and zones in the form of Regional One Health Taskforces. The Jigjiga University One Health Initiative (JOHI) contributed in establishing these taskforces.

The Jigjiga University One Health Initiative (JOHI)

The Jigjiga University One Health Initiative is one of Ethiopia's ad-hoc multi-sectoral engagements to preclude threats from zoonotic diseases. It is a research and development partnership between Jigjiga University (JJU) and Armauer Hansen Research Institute (AHRI) in Ethiopia and the Swiss Tropical and Public Health Institute (Swiss TPH), funded by SDC. The aim of the Initiative is to establish research on health as well as teaching and development capacities in this field at Jigjiga University. Integrated health systems will then lead to improved health and wellbeing of pastoralist communities in the Somali Regional State of Ethiopia (SRS) over a period of 10 to 12 years in two phases (2015-2025).

The first phase of implementation concentrates on building up the research and teaching capacities of JJU and establishes systems knowledge on human and animal health from 2015-2020. Jigjiga University is the only educational and research institution in the entire Somali Regional State of Ethiopia (see Box). Around 10,000 students are currently enrolled at the university. Locally adapted interventions have been developed from early research results and are currently being tested. All research planning is based on regularly recurring participatory stakeholder processes engaging academic scientists with authorities and communities for the identification of priorities and the validation of intervention plans. Good practices tested by JJU can then be adopted by the regional government. The community would thus benefit from this increased knowledge through better targeted interventions and services by public and animal health authorities. For example a novel tuberculosis control intervention adapted to mobile pastoralists is currently being tested. Similarly, testing is in progress of portable water filters to provide safe drinking water.

The next phase, starting in April 2021, will engage to further improve the health and resilience of Somali pastoralists and their animals. JJU is to become a centre of excellence in One Health which would contribute to establishing the health research capacity of two other universities, the University of Hargeisa and the National University of Somalia. These interventions can thus contribute to improved human and animal health, environmental management and livelihood opportunities for the region as a whole.

JOHI is using synergies with another One Health project, "One Health Units for Humans, Environment, Animals and Livelihoods" (HEAL). This regional project promotes sustainable rangeland management and access to integrated human and livestock health services in Ethiopia, Somalia and Kenya. While JOHI focuses on research and education, HEAL strengthens the development of integrated One Health services that are more accessible to pastoral groups.

What has been reached so far?

The Jigjiga University One Health Initiative contributed to the establishment of a coordination mechanism, the so-called Somali Regional One Health Taskforce, in July 2019. The Taskforce consists of representatives from the Regional Health bureau, the Regional livestock and pastoralist development bureau, Jigjiga University (as a secretary), and the Bureau of agriculture and natural resources. In addition, the representatives from media, UN agencies and NGOs participate. The goal of this taskforce is to coordinate One Health initiatives in the region and establish mechanisms for collaboration and coordination of multi-sectoral engagements. These mechanisms include, thus far, sharing reports of human and livestock disease outbreaks, coordinating the response and conducting after-action review.

In January 2020, JOHI established a molecular diagnostic laboratory at Jigjiga University. In March 2020, the Somali Regional Government suggested to JOHI that the new laboratory could be used for COVID-19 diagnosis. Today, the JOHI laboratory is the only COVID-19 diagnostic centre in the Somali Region of Ethiopia and has done several thousand tests. Currently, a survey is planned to assess the proportion of the population exposed to SARS-CoV-2 virus.

The way forward

The JOHI project at Jigjiga University contributes to research and development capacities for a future centre of excellence in One Health research in the Somali Regional State of Ethiopia. Locally adapted interventions for better health and wellbeing of the pastoralist and agro-pastoralist communities and their animals lead to a better resilience against the odds of climatic and social threats. Strengthening of communities and associative movements contributes to better livelihoods, focusing on women and remote communities. Contributions to novel adapted policies are bolstering institutions at regional and federal level and in the greater Horn of Africa.

PASTORALISTS IN THE SOMALI REGIONAL STATE

In Ethiopia, there are about nine million pastoralists (approximately ten per cent of the total population), half of whom alone are located in the Somali Regional State (SRS). These areas are vital to the national economy as their livestock production accounts for a substantial share of agricultural GDP. Yet the lowlands and their inhabitants have long been politically and economically marginalised. Such neglect has hindered the improvement of public services over time and the impact of pastoralists' voices on national and regional agendas.

The SRS is one of the least developed parts of the country, and is severely underserved in terms of basic infrastructure. It experiences major human and animal health concerns, mostly attributable to these systemic challenges and insufficient understanding of the specific needs of (semi-) nomadic, livestock-dependent populations.

Jakob Zinsstag is a veterinary epidemiologist. He is deputy head of the Epidemiology and Public Health department at the Swiss Tropical and Public Health Institute (Swiss TPH), an associated institute of the University of Basel.
Lensse Gobu is Health Programme Officer for the Swiss Agency for Development and Cooperation, Embassy of Switzerland in Addis Ababa, Ethiopia.
Rea Tschopp is a veterinary epidemiologist. She is head of the One Health Unit at the Armauer Hansen Research Institute and project group leader (One Health East Africa) at Swiss TPH.
Mohammed Ibrahim Abdikadir is a veterinary epidemiologist. He is assistant professor at the College of Veterinary Medicine of Jigjiga University, Ethiopa.
Contact: jakob.zinsstag@swisstph.ch

References: **www.rural21.com**

Towards better livelihoods of livestock-keeping communities

Translate scientific evidence into sustainable changes for livestock-keeping communities in low- and middle-income countries – that is the goal the International Livestock Research Institute (ILRI) has set itself. Our author describes which approaches come to bear in this context, what the role of the communities themselves is in this process and which hurdles still have to be cleared to establish the One Health approach on a broad base.

By Kristina Roesel

The International Livestock Research Institute (ILRI) and partners have followed and promoted a One Health approach for decades. While the core activities are research, the purpose of the research itself is to provide a scientific basis for sustainable changes for livestock-keeping communities in low- and middle-income countries. What is important here is that research does not only evolve around diseases transmissible between animals and humans but also focuses on sustainably increasing farm productivity for better livelihood and nutrition outcomes without contaminating or exploiting natural resources. This article is a small snapshot of examples from ILRI's activities in sub-Saharan Africa. Similar approaches are used in the projects implemented in Southeast Asia.

Livestock keepers in Morogoro, Tanzania, examine a poster used to obtain informed consent for research on dairy diseases. Photo: ILRI/ Tarni Cooper

Participatory approaches in research with communities

For us, capacity development and dissemination already start at the point of data collection. For more than 20 years, we have used participatory methods developed in social science to study zoonotic and non-zoonotic diseases. To eradicate rinderpest, participatory epidemiology has helped to sensitise communities, map hotpots of disease transmission and co-develop control options to eventually eradicate the disease.

Today, we use participatory methods to prioritise health issues relevant to the communities, identify patterns of disease occurrence (temporal-seasonal, cultural, economic) and determine how they relate to externalities such as animal movements or school terms. We discuss how these issues are currently managed in and by the communities, constraints on how to improve control measures, and how to improve adaptation of available solutions (the upper Box shows an example). While researchers use the data gathered to discuss them with the scientific communities, the participants consider these activities as a training because they may otherwise never have come together with peers to discuss a certain topic of concern to the entire community. In terms of disease surveillance, researchers are enabled to identify health priorities without being too biased towards one focus disease. Participatory appraisals are coupled with prevalence studies or other surveys on disease agents. In the recent past, we have identified zoonotic diseases that had never been reported from countries before (e.g. diamond skin disease in pigs), or for which only anecdotal reports existed; or we have learned from the communities that there are many early warning signs of zoonotic diseases (e.g. sudden die-off of antelopes around water holes as a precursor for an anthrax outbreak).

Reporting back to and reflecting with the communities

Part of the ILRI protocol on research ethics requires the researchers take the findings of studies back to the communities where the research was conducted. This mechanism ties good scientific practice with developmental impact because the communities (including their leaders) are more aware of potential health problems in their communities and potential implications for their livelihoods. This approach of community conversations has since been scaled nationally and in terms of conversation topics, such as antimicrobial resistance.

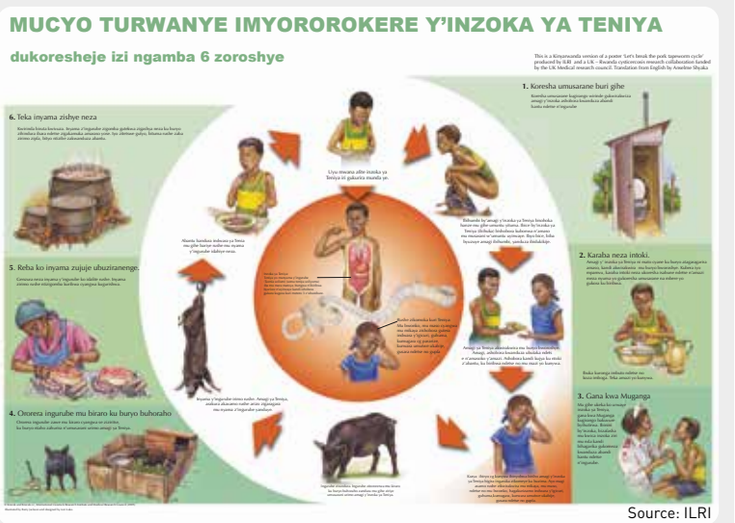
In 2012, the CGIAR Research Program on Livestock, led by ILRI, started implementing value chain-based programmes in Ethiopia (small ruminants), Tanzania (dairy), Uganda (pigs) and Vietnam (pigs). The first phase of the programme started by extensively mapping the value chains in focus, including their actors and stakeholders, identifying and quan-

A VACCINE HAS BEEN DEVELOPED – NOW WHAT?

Taenia solium, a tapeworm transmitted between pigs and people, has long been contributing to the health burden in poor, pig-keeping communities in Africa, Asia and the Americas. Humans harbour the adult worm and infect pigs and other people when they practise open defecation. Pigs and people develop cysts in muscle and brain tissue when ingesting the eggs from the environment. In pigs, these cysts do not cause much harm as they are usually slaughtered at the end of the growth period, and in most cases, an infection is not noticed until slaughter. In humans, however, *Taenia solium* cysts in the brain can lead to epilepsy and other neurological malfunctions. The adult worm can develop in humans when they ingest undercooked pork with viable cysts.

Recently a vaccine has been developed for pigs to avoid cysts developing at production and consequently preventing humans from getting infected. But farmers do not see the benefit of buying the vaccine because they do not receive more money for each kilogram of pork, even if it is "tape-worm-free". The vaccine comes in a package with a dewormer; in case the pig already caught the infection prior to the vaccination, cysts are cleared from the system. This dewormer also kills other gastrointestinal worms that cause a pig not to gain as much as if it was free of worms.

"BREAKING THE TAPEWORM CYCLE". An extension poster in Kinyarwanda language.



Source: ILRI

This is potentially the motivation for a farmer to consider buying this intervention package, as it will help him sell bigger pigs at a better price.

tifying health, economic and social burdens and discussing solutions (using participatory approaches). These included feeding animals (and the competition with human food resources), husbandry practices, access to service, knowledge and extension. Human health and nutrition aspects were covered by the CGIAR Research Program on Agriculture for Nutrition and Health through the Safe Food, Fair Food project (funded by Deutsche Gesellschaft für Internationale Zusammenarbeit – GIZ) which investigated foodborne zoonoses from farm to fork by leveraging the value chain approach. Thanks to the long-term intention of these programmes (ten years), it was possible to form strong bonds with communities, their leaders, the local public and the private sector (see Box below). In all of the countries where the programme was implemented, mobile phone-based and other multi-stakeholder platforms have been developed and are running.

Training from grassroot to policy level

One Health training at **graduate level** has long been integrated into the research conducted by ILRI and partners. Fellows are often staff of national research and government institutions, such as the Kenya Medical Research Institute, the Ethiopian Public Health Institute and the Ugandan National Animal Disease Diagnostics and Epidemiology Centre. These departments are embedded in the countries' Ministries of Agriculture and/or Health and therefore directly benefit from working with ILRI (and other CGIAR centres) as they have access to state-of-the art technology and an international network.

Programmes such as the USAID-funded Africa One Health University Network (AFRO-HUN), the Afrique One-African Science Partnership for Intervention Research Excellence (ASPIRE) funded by the Wellcome Trust, the UK Aid-funded One Health Regional Network for Africa (HORN), and the Southern African Centre for Infectious Disease Surveillance (SACIDS) Foundation for One Health have developed modules for One Health training at the graduate level for the past decade and more. These pan-African training programmes will hopefully shape future leadership in One Health.

mPIG: MOBILE SMS LEARNING FOR PIGS

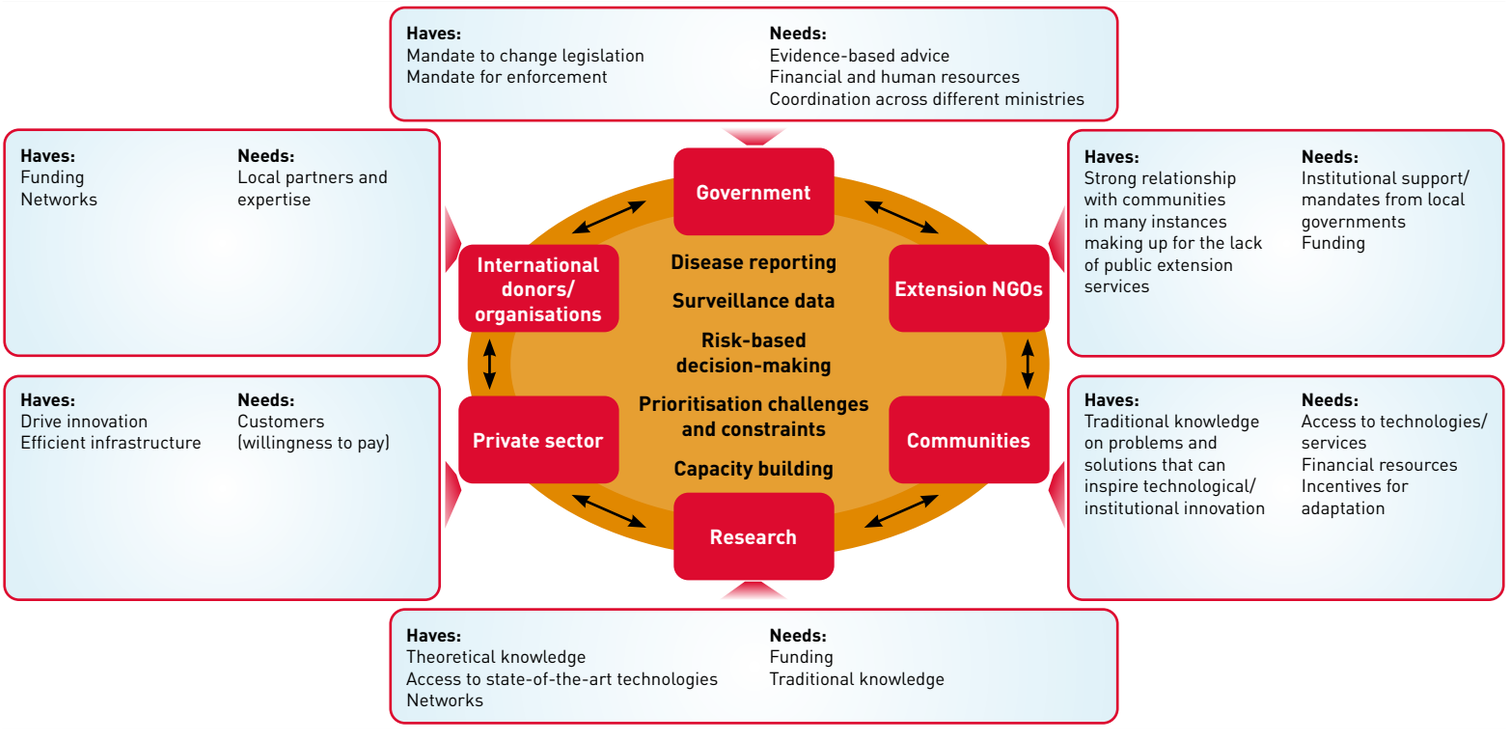
Based on the findings from the assessment of pig value chains in Uganda, we developed a set of 15 messages for 800 pig farmers in one of the poorest pig-keeping community. Pigs are monogastrics like humans, and since many of the smallholder pigs are cared for by women (e.g. mothers), the sms (in local languages) included messages on good pig husbandry and welfare but also on human nutrition and good hygienic practices to avoid foodborne and other zoonotic diseases. These messages were extensively pretested, participants taught in the use of the phone, and an electronic platform was set up for automated messaging. Following the pilot intervention, we held group discussions with the users to identify constraints to the scaling of the intervention (e.g. varying literacy levels, inequity in phone use and phone networks, willingness to pay for the service, among others).

COMMUNITY CONVERSATIONS IN THE HIGHLANDS OF ETHIOPIA

Teams of the International Livestock Research Institute (ILRI) and the International Center for Agricultural Research in the Dry Areas (ICARDA), in collaboration with regional research centres and district development partners in Ethiopia, facilitated a series of community conversations on gender roles and sharing of workload, zoonotic diseases (e.g. boiling milk and cooking meat), livestock ownership and decision-making as well as access to information and extension services in 2018. Participants were guided through a set of reflective questions to capture and discuss their experiences and stories about the benefits of the conversations and the changes they had made individually and as a household, community or group. Beyond the discussions facilitated by the research teams, the participants took the messages learnt to their own community's communication channels, such as bible study, groups, village savings groups, women's groups, social gatherings and community meetings.

The district officials also reflected on their key learning: "We have been practising a top-down extension approach with a focus on technology not on people, but community conversations are the way we are supposed to do our work with the community [...] that bring a change in attitudes and practices in the community. Since then we have started consulting women as well, which before had not been practice."

IMPLEMENTING THE ONE HEALTH APPROACH – HAVES AND NEEDS



At **policy level**, engagement is more challenging due to limited human and financial resources that draw the attention to more urgent problems and away from long-term investments in strengthening health systems. Sharing resources and information across government departments is lacking, and this problem is hard to solve. Some countries, such as Kenya, spearheaded the process over time to collaborate more closely in human, livestock, wildlife and environment health through their zoonotic disease unit hosted at the Ministry of Health. In many other countries, the benefits of this collaboration have not been acknowledged yet or are difficult to implement. Similar to other partners in numerous countries, we are trying to engage political decision-makers by providing them short and less technical policy briefs and compilations of those or inviting them to planning and stakeholder meetings. In the wake of the Corona pandemic, many activities have successfully been shifted to virtual meetings enabling interested stakeholders in contributing and listening, such as the Community of Practice webinar series organised by the One Health Units for Humans, Environment, Animals and Livelihoods (HEAL) project.

At **grassroots level**, we still heavily depend on the government extension service, which is usually extremely underfunded and understaffed. Non-governmental organisations such as Vétérinaires sans frontières (VSF), the Foundation of Netherlands Volunteers (SNV), TechnoServe, Land O'Lakes and many others usually try to cover this gap with resources mobilised outside the African continent through donations or bilateral grants. In partnership with ILRI and Comitato Collaborazione Medica (CCM), VSF-Suisse is implementing the HEAL project in Ethiopia, Kenya and Somalia. The consortium is currently working on operationalising community-based One Health units, especially in pastoralist areas where access to extension services is even more inadequate. These units are meant to provide technical advice on human and animal health as well as rangeland and natural resource management. At the same time, they are expected to serve as a point of referral and surveillance, an interface between the pastoralist communities and the government.

The ILRI-led project "Boosting Uganda's Investments for Livestock Development" (BUILD) project (funded by the German Development Ministry – BMZ) is a further example. It investigates (zoonotic) animal disease outbreaks jointly with the Ugandan Ministry of Agriculture and VSF-Germany. While researchers collect samples from animals (and humans), the extension NGO provides extension advise to affected farmers on how to detect, report and contain the disease. The data collected will be used for research on intervention options (such as which vaccine to use), but also to provide the government with decision-support tools (such as risk maps for disease hotspots in the country) and surveillance data.

Synergies and complementation for greater impact

In order to concentrate and disseminate One Health knowledge and take advantage of synergies, the ILRI-led, BMZ-funded One Health Research, Education and Outreach Centre in Africa (OHRECA) was founded in 2020. It aims to facilitate the exchange, complementation and sharing of knowledge and resources across sub-Saharan Africa. Building on more than 20 years of One Health research for development, we hope to bring all the initiatives mentioned above and beyond together towards a common goal.

Kristina Roesel is a scientist in the Animal and Human Health programme at the International Livestock Research Institute, based in Nairobi, Kenya. She joined ILRI in 2011 and currently heads a new ILRI-led BMZ investment on improving animal and human health in Uganda and helps in conceptualising the BMZ-funded ILRI One Health centre for Africa.
Contact: K.Roesel@cgiar.org

Further reading: **www.rural21.com**

Focusing on infectious diseases is not enough

Diversity of settings and the nature of the world's health challenges had been calling for linking up expertise from different disciplines long before the One Health approach was gaining momentum. Our authors describe what German development cooperation has learnt from past experiences with interdisciplinary teams in the field of human, animal and environmental health and how it is preparing for the increasing demands for One Health.

By Lea Knopf, Renate Herrmann and Tobias Feldt*

Sustainable solutions for the world's interconnected challenges need joint knowledge creation and have to include expertise from local to global level. The German Federal Government started to introduce policy directions in the field of One Health a decade ago, and alongside other relevant ministries, the German Federal Ministry for Economic Cooperation and Development (BMZ) has amplified its engagement on this topic over the last three years. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has longstanding experience in translating such policies into tangible outcomes across the globe. Such collaborative efforts specifically at the interface of environment, biodiversity, human and animal health, food security and land management have led to closer cooperation between actors of the public and private sectors from the South and the North and can make the world a safer place – for all. This article showcases selected past and on-going experiences of cross-sectoral approaches in the field of human, animal and environmental health.

Multi-facetted problems call for interdisciplinary teams

Livestock farming in many countries is directly affected by the loss of natural pasture resources (population growth, over-use of land, intensification of agriculture, cash crop production) and climate change (desertification, changing dry and wet season patterns). This usually leads to poorer food security and land use conflicts, and it affects the health of people and animals. In Uganda, the BMZ fostered cooperation and cross-sectoral planning for previously independently-led development initiatives between the country's ministries and stakeholders of relevant sectors. On the implementing partner side GIZ paired such initiatives with on-the-ground education and training in agriculture and livestock husbandry to increase technical, business and nutritional skills of farmers. Better adapted methods for resource-saving crop and livestock production, food processing and participatory planning of land use have evolved from such collaborations and have been disseminated to other settings where they have improved the resilience of farmers to face climate change and contributed to a better socio-economic and health situation of the communities. Lessons learnt in such settings have added another perspective. Ensuring women's access to and control of resources such as land, livestock, markets, information and credit strengthens their influence and social empowerment. Designing livestock development programmes with a targeted gender approach therefore improves impact in terms of poverty reduction and food security.

In Uganda, ongoing work aims at improving health of food-producing livestock to boost livelihoods of farmers and increasing the safety of animal products and, ultimately, consumer and occupational health through adapted strategies. This model, partially implemented in Kenya, too, combines information sources from multiple disciplines along the food chain to enhance early detection of diseases or antimicrobial resistance at the human-livestock interface. Likewise, in Southeast Asia, poor sanitation and a lack of safe drinking water contribute to the spread of infectious diseases. In Cambodia, Indonesia, Lao PDR and the Philippines, the strategy of BMZ and implementing partners went beyond raising people's awareness of classical hygiene measures (washing hands and using clean toilets, deworming of children) for better health of communities. Involving the educational sector meaningfully improved environmental awareness of the protection and conservation of water resources or sustainable, safe water use in agriculture in communities, too. In Cambodia, for instance, these topics were additionally integrated into school curricula.

The German Epidemic Preparedness Team (SEEG), established in 2015, supports German development cooperation partner countries and partner organisations in preparing for and rapidly responding to disease outbreaks. SEEG has associated necessary disciplines according to its knowledge of the conditions on the ground and to help to quickly identify and address possible weaknesses together with the partners in difficult situations such as the outbreak of disease. The lesson learnt from interdisciplinary work is that there is a long way to go from recognising the need for multi-disciplinary teams, constituting them and then to effectively working and communicating as one assimilated team.

The One Health approach as an extension of the previous?

The recent emergence of yet another epidemic with a global impact exemplifies the stark reality of the interconnection of human, animal and environmental health. There has been increasing international recognition that collaboration between at least the sectors mentioned above would be crucial to efficiently tackling today's and tomorrow's threats to health, social justice and peace. The lessons learnt from the 2014-2016 Ebola epidemic in West Africa highlighted the need to strengthen health systems under a One Health approach to ensure that countries are better equipped to rapidly detect and efficiently respond to disease outbreaks at their source. The strategies and work plans of the German Federal Government and its development partners have incorporated these lessons and declared 'One Health' a priority area of the country's development cooperation.

In partnership with relevant other German ministries, the BMZ has pursued a multi-axis policy to prevent and mitigate threats at the human-animal-environment interface. Bilateral agreements for capacity development with partner countries or entire regions have been in place since the start; financial and technical support alongside the World Bank to strengthen programmes of key international organisations, in particular the Tripartite organisations (the UN Food and Agriculture Organization [FAO], the World Organisation for Animal Health [OIE] and the World Health Organization [WHO]) which are setting the One Health policies and implementing them worldwide, have regularly been renewed. Another pillar has been dedicated to investments in re-

Left: Cross-border field simulation exercise for pandemic preparedness in the East African Community (EAC).

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Right: Training of laboratory personnel by a team of the Rapid Deployment Expert Group on Health (SEEG) for the use of a SARS-CoV-2 detection kit. Cochabamba/ Bolivia.

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search coalitions, be it in Germany, Europe or Germany's development cooperation partner countries, to better understand pertinent factors of interdependence of biodiversity, environmental health, and human and veterinary medicine. The decision to create a dedicated One Health Unit within the BMZ shows the political leverage of the One Health approach in development cooperation. GIZ, as part of international development cooperation, supports the German Federal Government's call to improve planification and coordination of activities between ministries, partners as well as the wider One Health community with a dedicated One Health team.

Where the One Health approach is already coming to bear

Nevertheless, a number of large-scale projects are already employing a One Health approach:

In close collaboration with its political partner, the Secretariat of the East African Community (EAC), GIZ, commissioned by BMZ, enhanced pandemic preparedness and strengthened coordination in the EAC region in a cross-border field simulation exercise between Kenya and Tanzania. The innovative peace-time capacity development "Support to Pandemic Preparedness in the EAC region" is a good example of One Health in practice. It brought together key disciplines and sectors for practical exercises in integrative epidemic management, with professionals from a medical and veterinary, climate, environmental and agricultural background, and further representatives from trade, tourism, communities, the military and the media. As a future outcome, the EAC countries are currently preparing a regional One Health Strategy.

In 2018, the Economic Community of West African States (ECOWAS) and the West African Health Organization (WAHO), supported by international partners, conducted a large-scale zoonotic disease prioritisation exercise with representatives of human, animal and environmental sectors of its member states to inform the region's One Health strategy under development. GIZ's "Regional Programme Support to Pandemic Prevention in the ECOWAS Region (RPPP)" laid a groundwork for this by supporting a regional strategy which aims at improving coordination on health programmes within the region and between institutions and assisting member states in better implementing the International Health Regulations. The RPPP applies the One Health approach in all its interventions and activities across its four thematic fields of operation for enhancing the capacities for pandemic preparedness and control in the region. The RPPP, in collaboration with academia, has also incorporated the One Health approach in the ongoing capacity building programme for pandemic preparedness and control. Regional and national human resources benefit from tailored training e-learning modules and topic-specific workshops (e.g. risk communication, inter-institutional coordination and simulation exercises for outbreak management).

Looking at support for international organisations and the One Health approach, Germany is a major donor to the Tripartite's new Multi-Partner Trust Fund to combat antimicrobial resistance (AMR) globally and using a cross-sectoral approach. The Trust Fund aims at scaling up the Tripartite efforts to support countries to mitigate the immediate threat of AMR, which has been a Tripartite top priority for One Health collaboration. As a supplementary initiative, BMZ, the International Livestock Research Institute (ILRI) and counterparts are about to launch operational research at the human-livestock interface in selected partner countries, where baseline data on AMR are scarce and are urgently needed to inform the strategic directions in those settings.

Germany dedicated supplementary funds to the WHO-led fight against neglected tropical diseases (NTDs). Many of the NTDs have an animal health or environmental component and affect the world's poorest. Therefore, combating NTDs would benefit from an enhanced cross-sectoral approach, such as One Health and Water, Sanitation and Hygiene (WASH), which are already successful, integral parts of health programmes in an increasing number of countries. Another example is the BMZ contribution of resources to OIE's next generation World Animal Health Information System, which will improve timely reporting of sanitary information by countries, including on zoonoses. This is one example of how digital surveillance and information systems facilitate timely, automated exchanges with (health) information systems of other sectors, which allows for integrated data analysis. A BMZ region-specific support to OIE targets capacity building of veterinary workforce in remote areas to fight against transboundary animal diseases and food insecurity, and operationalise the One Health approach on the example of elimination of dog-mediated rabies in West Africa. Preparedness of

Left: Veterinary services in the Horn of Africa help to control transboundary animal diseases and ensure food security.

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Right: Human encroachment into natural habitats and wildlife trade bear the risk of zoonotic disease transmission and threats to biodiversity. A wet market in Iquitos, Peru.

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veterinary services helps to respond to the climate change-induced shift in epidemiological disease patterns. Policies to enhance climate-smart agriculture management strategies are urgently needed to reduce greenhouse gas emissions, and this goes hand in hand with a more preventive, inter-sectoral approach to climate-intelligent livestock production, the control of livestock diseases and zoonoses.

More recently the BMZ initiated the One Health Research, Education and Outreach Centre for Africa (OHRECA), in close collaboration with and based at ILRI in Kenya. Specifically, the new centre will help develop capacities, support One Health initiatives on the continent and refine integration of evidence, policy and practice (see article on pages 22). The ambitious workplan and first results of OHRECA will serve not only as model for other world regions, but also as a starting point, to gain a better overview of existing One Health initiatives and One Health networks on the continent to build on and learn from.

Similarly, research agendas are undergoing a paradigm shift. The bolstering of Germany-based One Health scientific research among institutions with an international outreach has led to more collaborative efforts between traditionally only human health or animal health-oriented institutions and the creation of sector-overarching bodies (e.g. the German One Health Initiative, the new Institute of International Animal Health/ One Health at the Friedrich Loeffler Institute).

The environmental sector is not yet satisfactorily integrated into these efforts, but the established structures are already partnering in development cooperation for capacity development and applied research world-wide. And there are promising approaches related to the reduction of risks of zoonotic disease transmission and threats to biodiversity due to human encroachment into natural habitats and wildlife trade (see article on page 32). A recently launched 'International Alliance against Health Risks in the Trade in Wildlife and its Products', a joint initiative of the BMZ and Germany's Environment Ministry (BMU) together with political and civil society actors, will tackle these challenges. BMZ has furthermore been elaborating strategies to sustainably improve biodiversity and protected area management: It is already a major development partner in accelerating political recognition of the importance of biodiversity conservation topics and optimising information sharing between sectors and countries. Combined with GIZ's efforts involving local communities to improve local food security, sustainable land use management and adapted income generation, BMZ's strategies decrease threats to ecosystems.

Next steps and vision for the future

The public and media perception of the One Health approach has gained impetus through epidemics with predominantly severe consequences for human health like Ebola or the ongoing COVID-19 pandemic. However, the One Health concept as conceived by the professionals involves a much broader consideration of the approach: There is a yet under-used potential to improve health and wellbeing of all, humans, domestic animals, wildlife and the environment in a sustainable way, not just in the short run regarding the emergence of infectious diseases. In practice, biodiversity, conservation and ecosystem dynamics have clearly been orphaned in the assessment of disease risks, One Health policies or research agendas, compared to the rather narrow human-livestock interconnection. The time is now for the international development cooperation to prepare for a One Health approach that embraces sustainable use of biodiversity for food and agriculture, because it provides multiple, simultaneous benefits for human, animal and ecosystem health.

We have learnt that the balance between humans, animals and the environment remains fragile and complex. It merits more collaborative efforts and more vibrant exchanges between key professionals in the North, the South and across disciplines to secure incremental societal benefits through the implementation of a true One Health approach.

Dr Lea Knopf is Advisor for One Health at Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in Bonn, Germany.
Contact: lea.knopf@giz.de
Dr Renate Herrmann is Advisor for Animal Health at GIZ.
Contact: renate.herrmann@giz.de
Dr Tobias Feldt is Advisor for Animal Husbandry at GIZ.
Contact: tobias.feldt@giz.de

** With contributions from **Sabine Ablefoni, Dr Irene Lukassowitz, Ingrid Prem** and **Dr Christine Wolf**, all GIZ.*

“We have to prepare for the unexpected”

In August, Germany's development ministry set up a division concentrating on One Health topics. Parliamentary State Secretary Maria Flachsbarth on knowledge gaps at the human-animal-environment interface, the link between One Health and food security, and lessons learnt from previous pandemics.

Ms Flachsbarth, your Ministry recently set up a One Health Unit. Why do we need such a unit?

The German Government has long been campaigning for stronger interdisciplinary cooperation between human and veterinary medicine and the environmental sector. The need for interdisciplinary cooperation has once again become apparent with the global COVID-19 crisis. We have therefore decided to further step up our engagement for One Health and set up a new Directorate for “Global Health; pandemic prevention; One Health” at the Federal Ministry for Economic Cooperation and Development, the BMZ. Since the 1st August 2020, a new Division has been dealing specifically with One Health topics. In this manner, we are boosting our capacity to support interdisciplinary ventures in our partner countries.

Does “greater engagement” also mean “more finance”?

The increasing significance which we attribute to the One Health approach is also being underscored by more finance for health, combating pandemics and One Health. The Federal Parliament is to decide on the exact amounts in a few days' time. And then there are contributions to multilateral initiatives in the health sector. For example, we are supporting the Global Fund to Fight AIDS, Tuberculosis and Malaria alone with one billion euros for the period 2020 to 2022, making us the fourth largest donor to the Global Fund. The One Health sector is still quite young and is in a process of expansion, so that statements on development aren't yet possible. But I would already like to point to two new projects launched at Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). As of January 2021, a sector project on One Health will be advising us. In addition, from 2021 on, we will be financing a global project on the prevention of epidemics and pandemics with a One Health approach for three years in order to provide special support for partner countries and institutions implementing the One Health approach.

Photo: BMZ

Maria Flachsbarth is Parliamentary State Secretary to the German Federal Minister for Economic Cooperation and Development. She holds doctoral and postgraduate degrees in Veterinary Medicine from the University of Veterinary Medicine (TiHo) in Hanover, Germany.

Cooperation across sector boundaries is at the core of One Health. How does this work in German politics in concrete terms?

The Federal Government recently adopted the “Global Health” strategy, which takes the One Health approach into account. I would explicitly like to refer to two concrete, cross-department Federal Government measures relating to One Health. One of them is the “National Research Platform for Zoonoses” funded by the Federal Ministry of Education and Research (BMBF), the Federal Ministry of Food and Agriculture (BMG), the Federal Ministry of Health (BMG) and the Federal Ministry of Defence (BMVg). It is an information and service network for all scientists working in the field of zoonosis research in Germany. With its more than 1,000 members, it is an established pillar of the zoonosis research community in Germany. There is a further joint approach centring on the topic of antimicrobial resistance. The Federal Government is addressing this important topic with the German Antibiotics Resistance Strategy – DART – and is continuing to develop that strategy. Here too, we intend to act in concert as the Federal Government. In the past, it was more the individual line ministries (including the BMEL, BMBF and BMG) which were active, but we as the BMZ are playing an ever stronger political role as a powerful actor in our partner countries. For we must surely all be aware that global problems can only be solved globally. And with our work with and in our partner countries, but also with our multilateral partners, we are contributing essential experience.

In addition, again and again, individual departments have joined forces to implement joint projects. From 2013 to 2018, for example, the BMBF and the BMZ supported the development of six German-African research networks for five years in the context of the GlobE – Global Food Security funding initiative.

Do we know enough about the interaction between human, animal and environmental health?

We already know a great deal about interaction between human and animal health. Let's take the example of zoonoses, diseases that can jump from animals to humans, such as brucellosis, bovine tuberculosis or rabies. Up to just a few decades ago, these illnesses had accompanied our lives and posed a daily threat for many. Diseases caused by the consumption of animal food, such as campylobacteriosis or *Salmonella* and *E. coli* infections, are a danger to human health. But our knowledge and the consistent application of measures, especially in the field of food safety, have resulted in some illnesses, such as brucellosis or tuberculosis, nowadays hardly being a problem in Europe. Nevertheless, they are still very much a problem in our partner countries.

We lack knowledge at the interface between human and animal health and environmental health. We know that new threats come first and foremost from the wildlife area, as is the case now with COVID-19. More than 70 of the new pathogens, including a large number of coronaviruses, among them SARS-CoV-1&2 and MERS-CoV, come from wild animals. Unfortunately, we don't know which pathogens will next become a threat and when this is going to happen. So we need good prevention and early-warning systems, which however is an extremely complicated issue. For many wild animals don't get ill from the microorganisms and viruses which can trigger epidemics or pandemics in humans. Furthermore, we lack knowledge about the interaction between the environment and the areas of human and animal health. Just consider the consequences of climate change. We know that the climate

has a considerable influence on health and on carriers of diseases, such as blood-sucking insects. It is getting warmer, so that vectors like mosquitos can spread into new areas or other altitudes and spread previously unknown illnesses there, such as the West Nile virus and Chikungunya virus infections or malaria. But there are certainly many interactions which we are as yet unaware of.

What about food security in this context?

Of course, a sufficient supply of safe, healthy food is the basis of health and development. But we also know that food must not only be healthy, it also has to be produced in a healthy manner. What I mean here is that we can only produce our food sustainably if we consider interaction between agriculture and the environment. Our aim is to achieve closer collaboration between the actors in the three sectors of human, animal and environmental health as well as agriculture and the areas of water and wastewater. No sector can now manage this on its own.

For us, this also means that we are going to take a much more interdisciplinary approach and pull together development cooperation projects from various different sectors. For example, in sustainable agriculture, we are putting an even greater emphasis on the protection of the environment and natural resources, e.g. through agro-ecology, and are linking up agriculture with health aspects. In this manner, the interdisciplinary One Health approach is contributing to food security – and vice versa.

Where do you see the greatest obstacles to implementing this approach in the partner countries?

Many of our partner countries have already experienced outbreaks of diseases calling for interdisciplinary action: Ebola in West Africa, Rift Valley Fever in East Africa, SARS, MERS and Nipah virus infections in Asia. So in our partner countries, the One Health approach isn't new, and a general understanding of the issue exists in many countries.

I believe that the biggest obstacles are the absence of structures, for example in the veterinary sector, or in implementing phytosanitary measures, that is, measures meant to prevent the introduction of invasive species. The lack of authorisation structures and regulations is a problem regarding herbicides and medicines. Who will make sure that they are not harming the environment and health, or that the substances are applied correctly, so that no resistance to them develops? So we have to support our partners in developing structures and integrating the One Health approach in them. We can further strengthen this by building networks. Some countries have already developed One Health strategies – here, we can definitely learn from each other. And of course education and information is important, concerning both certain practices and the benefits of One Health measures. For prevention is always better than cure.

Drawing a comparison with the outbreaks of H5N1 or SARS, nearly 20 years ago, are we better prepared to cope with pandemics today?

The H5N1 avian flu disease taught us a lot. It certainly was a wake-up call, and prompted the WHO, the FAO and the World Organization for Animal Health (OIE) to join forces as the Tripartite. Although the One Health approach wasn't new at this stage, the Tripartite refined the concept of One Health and established it at international level. Early-warning systems such as GLEWS – Global Early Warning System – have evolved, and surveillance, diagnosis and information systems have been improved and linked up in the shape of Regional Networks in Asia and Africa.

These structures provide us with a considerably improved arsenal of tools to address new outbreaks of diseases with an epidemic or pandemic potential. But it is also clear that every pathogen has its own specific properties and is therefore new to us. We don't know how to detect or treat it, and neither do we know anything about its epidemiology or the progression of the disease. Thus one lesson from the past and from the present situation is that we have to prepare for the unexpected. Therefore, we need to invest in structural changes: preventing instead of combating diseases! For instance with better hygiene standards and better standards and checks in the area of food safety, including in livestock and wild animal markets. We generally have to relieve the health systems of pressure from infectious diseases, including neglected tropical diseases.

Combating zoonoses bears a particular conflict potential, for example regarding forests – just take non-timber products. How can a balance of interests be achieved here?

First of all, we have to distinguish here between the sustainable use of forests and their products and the excessive exploitation and destruction of forests. The latter are far more dangerous, including with regard to zoonoses and their spread. Let me give you two examples. When tropical forests were destroyed in West Africa, flying foxes, which carry the Ebola virus, settled in the proximity of villages and towns, massively accelerating infection. Or take the relentless hunting of the pangolin, which is again and again mentioned as a transmitter of viruses. It is the most frequently poached animal and is illegally traded across the world – with the corresponding risk of infection for humans. This list could easily be continued. But this is something that is quite different from what the huge majority of indigenous communities are doing across the world. They make sustainable use of the forests and their products and at most engage in local trading of these products. Moreover, they have traditional knowledge which has taught them gentler, more careful handling of the forest. In my opinion, it's important to combine this knowledge with modern veterinary science knowledge in order to jointly develop and improve effective early-warning systems for wildlife zoonoses in tropical forest regions – and of course also to sensitise and inform the indigenous communities, who may be the first to be affected by outbreaks. I would concede that here and there, this can result in indigenous communities also having to accept restrictions of use – for their own and for everyone's wellbeing. This is why it is so important for us to offer these groups alternative sources of income. Here, development cooperation comes into play, and it has answers to these issues.

Where are we going to be in 2030 regarding the implementation of the One Health approach?

If we carry on what we are doing, which I'm confident we are going to, then we will have achieved quite a lot in ten years' time. My ministry has made One Health one of its ten "initiative areas", and in the strategy which we have now adopted, we have set ourselves two concrete targets which we seek to implement over the next four years. In this period, we are going to establish the topic as a firm part of our own work, but we will also be making progress internationally in promoting One Health. For One Health grows logically out of implementating the 2030 Agenda. In my view, poverty reduction, food security, health and the protection of our environment can only be achieved with a holistic approach. We have to protect our vital natural resources and must make agriculture more sustainable, and this is also exactly where One Health comes in. I would venture the forecast that in ten years' time, One Health will be quite commonplace in development cooperation.

Maria Flachsbarth was interviewed by Silvia Richter.

How can we make the livestock sector more resilient?

Livestock is a crucial link between people and the environment that can have both positive and negative effects. For a One Health approach, we need to re-balance the relationship between animals and land and weigh efficiency against resilience, our author maintains.

By Ilse Köhler-Rollefson

During the height of the COVID-19 lockdown, short and local livestock value chains remained relatively unscathed, while production systems depending on international inputs or on global markets for their output were heavily impacted and faltered. This was the message that came out loud and clear from the satellite regional meetings which preceded the latest meeting of the Global Agenda for Sustainable Livestock (GASL), a multi-stakeholder platform administered by the UN Food and Agriculture Organization (FAO), which was held in early September and centred on the impact of COVID-19 on the livestock sector. Furthermore, East Africa, West Africa and South/East Asia reported that pastoralism and local breeds had done remarkably well.

These observations underline the vulnerability of global livestock value chains and should urge us to restructure the livestock sector towards more reliance on local resources. What are the principles of resilient livestock economies that minimise the risk of disease outbreaks, including zoonoses, and that can both prevent and withstand such catastrophic events as the ones we are experiencing in 2020?

Local breeds can be important in decentralised value chains, as in camel dairy development in Rajasthan/ India.

Photo: Ilse Köhler-Rollefson

The advantages of local breeds

A resilient livestock sector begins with indigenous breeds that are adapted to local climatic and ecological conditions. These animals may have less output than the high-yielding breeds that have been promoted so heavily in recent years but they bear the huge advantage of being able to sustain themselves on locally available feed. They are not dependent on the obtainability of concentrate and feed mixtures whose supply may be interrupted. In case of feed shortages, they can even slow down their metabolic rate and ride out the crisis, as they have been selected for coping with such events for hundreds of years.

Indigenous breeds are resistant to diseases. Consider the Nari cattle, a long-horned dual-purpose breed from the Thar Desert in Rajasthan/India. Their breeders, the Raika pastoralists, profess that this breed does not suffer from any diseases whatsoever. Only when prodded repeatedly do they admit that their Nari cows might be affected by Foot and Mouth disease, but only in a very mild form that does not require any treatment.

By contrast, the improved breeds are much more susceptible to diseases. They are genetically programmed for quick growth or for yielding enormous output. As all their energy is channelled into meat, milk and egg production, they have no 'bandwidth' left to resist diseases. They cannot slow down their metabolism, and if their regular supply of high-quality feed is disrupted, they stop producing and perish.

The animals that are raised for meat production in industrial systems have to be slaughtered at a pre-ordained age for value chains to function. Broilers not culled at the right age put on so much weight that their legs can no longer carry them, while pigs become too big to fit into the standardised slaughtering processes. Having been intensively selected for maximum yields, the animals bred for such systems are genetically very homogeneous, and this creates ideal conditions for viruses to increase their potency.

By contrast, in pastoralist systems, herds consist not only of very disease-resistant animals, but are genetically diverse. As a risk minimis-

ing strategy, their owners purposefully strive for diversity in their holdings. They select for a large number of traits, including the ability to walk, obedience and maternal instincts that are not considered in scientific breeding programmes. Because of this genetic diversity, their animals make it much more difficult for viruses to spread, infect and multiply.

Another dangerous aspect of maintaining large numbers of high-yielding animals is that they tend to require frequent, or even routine, dosing with antibiotics to keep infections at bay. This in turns promotes antimicrobial resistance (AMR), culminating in the emergence of superbugs that cannot be controlled with existing drugs.

Dispersed production

Disease-causing organisms, whether viruses or bacteria, have a field day where large numbers of animals are kept together in tight spaces. They really have a walk-over when the immune system of livestock is compromised, as happens in industrial systems where animals have no opportunity for physical exercise and are stressed from being crowded together.

At the other end of the livestock production system, in pastoralist systems, movement and dispersal are inherent characteristics. In order to harvest scattered biomass, the animals have to walk and disperse. As research by animal nutritionists has shown, on their daily grazing rounds, they select their own individual 'menus' which differ seasonally. Having plants to choose from stimulates their appetites and reduces stress caused by boredom.

Of course, conditions for pastoralism do not exist everywhere, but providing animals the opportunity to move already helps. Nor are pastoralist herds free of diseases – latent infections with brucellosis and tuberculosis are to be reckoned with. But because animals are resilient and genetically more diverse, they present much less of a breeding ground for viruses and other disease-causing organisms.

Networks of smallholder farms keeping a limited number of animals belonging to local breeds have much to recommend them epidemiologically over large holdings of genetically identical animals. This would pertain to regions such as Southeast Asia, from which many dangerous epidemics such as avian influenza, swine flu and Nipah virus have emerged. Researchers attribute this to its transition from smallholder poultry and pig farming to industrial production. The exponential growth of the livestock sector here was made possible by a concurrent rise in feed imports. Take Vietnam as an example: Over the last 20 years, its feed imports grew from less than 1 million tons/year to 26 million tons/year. Corn and soy beans are grown in gigantic monocultures in one part of the world (the Americas) and then shipped to industrial livestock production units in Europe and Southeast Asia, where high-yielding animals transform it into meat, eggs and milk. This has increased the size and density of livestock holdings, creating ideal conditions for disease outbreaks.

Decentralised processing

Over the last several decades, smaller slaughter houses and dairies in North America and Europe have been eliminated to the extent that only a very limited number of giant processing units are now in operation. This set-up has been our undoing during the COVID-19 crisis. The cramped working conditions and humidity in slaughterhouses made workers prone to infection and led to the closure of many such facilities. As a result, millions of animals could not be slaughtered at the time they were meant to be and had to be 'euthanised' and disposed of in landfills. By contrast, the village-based slaughtering systems in countries such as India, where animals are slaughtered on demand, were not at all impacted.

If we want to foster resilient food production, we need to invest into networks of small processing units, be it dairies or slaughter houses. Such investment would create local jobs as well as bring gains in terms of animal welfare and reduce the use of fossil fuels by avoiding long transportation.

Healthy eco-systems, healthy diets

For a One Health approach, it is necessary to look not only at the quantity but also at the quality of livestock products, including their nutritional density. Fast-growing and high-yielding animals have higher water contents in their meat and milk. Livestock diets influence other aspects of their products as well, such as composition of saturated versus unsaturated fatty acids. Animals that are fed on concentrate produce different products than those feeding on a bio-diverse diet with health-enhancing phytochemicals, which are non-nutritive components present in plants that influence our body processes and can protect us from diseases, such as heart problems and even cancer. There are at least a thousand different phytochemicals, and so far only a few of them have been explored. The lack of such micro-nutrients and certain trace elements in fast-grown food makes it less satiating and therefore leads to overconsumption and obesity.

Resilience, local breeds, livelihoods, high-quality food – it's all one package

Resilience, conservation of biodiversity, rural livelihoods and high quality, tasty food are all part of the same package. Our drive for livestock efficiency has resulted in high yielding, but sensitive breeds, large livestock holdings but elimination of local livelihoods, over-supply of cheap meat and dairy, but loss of nutritional density and taste.

We can reverse the trend by creating decentralised value chains that build on local breeds and networks of small processing units. This is also the approach taken for camel dairy development in Rajasthan/India by the NGO Lokhit Pashu-Palak Sansthan (LPPS) and the local Camel Breeders Association. According to local knowledge, camels feed on 36 ayurvedic plants which makes their milk especially healthy. So with support from two NGOs in Germany (Misereror and the League for Pastoral Peoples), an effort has been on since 2016 to maintain the traditional nomadic system, rather than go for stall-feeding, and enable milk collection through a network of micro-dairies set up in the camel breeding area. This will ensure that the milk retains its much sought after health-enhancing qualities, the camels are kept happy in a herding system, the camel breeding community retains its livelihoods, and the landscape and its tourism value is enhanced by the presence of camels. It is a win-win situation for people, animals and the environment and personifies the One Health approach.

Ilse Köhler-Rollefson is a German veterinarian who has been based in India for the last 30 years. She is co-founder of the League for Pastoral Peoples and consults widely for FAO and other UN agencies.
Contact: ilse.koehlerroll@googlemail.com

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Encroachment into natural areas, and not wildlife per se, is increasing the threat of disease outbreaks.

Photo: Jörg Böthling

One Health and wildlife trade(-offs) – preventing future pandemics

Zoonotic diseases are on the increase. Reducing the risk of further pandemics requires action in a range of areas. Our authors look at the origins of pandemics and discuss some measures centring on a One Health approach that could be taken to prevent further outbreaks of devastating diseases.

By Kim Grützmacher, Chris Walzer, Susan Lieberman and Amanda Fine

The COVID-19 pandemic is a painful wake-up call reminding us of factors that promote disease emergence and highlighting the critical control points at which we can reduce the risk for future pandemics: human activities expanding contact with wildlife and their habitats, such as farming, logging, housing and infrastructure development, capture for trade, and hunting, all of which increase the potential for viruses to spill over into human populations. The next pandemic could emerge at any time and might be even worse than what we are experiencing now. It is up to us to change the odds in our favour.

Pandemic origins, trends and risks

The COVID-19 pandemic has had an unprecedented and catastrophic impact on global populations with tragic illness and suffering, loss of lives, and devastating consequences for the global economy and livelihoods, many of which will reach far into the future. COVID-19 is a zoonotic disease with a wildlife origin. The majority of new infectious diseases that have emerged in humans since the 1940s are zoonotic, and 72 per cent of these diseases have come from wildlife, including Ebola virus disease, HIV/AIDS, and the severe acute respiratory syndrome, SARS. The frequency at which these novel diseases are emerging is increasing over time and so is the proportion of those which originate in wildlife. Scientists estimate that there are around 1.7 million viruses which have not yet been discovered in mammals and birds, of which about 700,000 may have the potential to jump to humans.

However, wild animals per se do not increase disease risk. It is the human activities that expand contact with wild habitats, including human encroachment into natural areas for hunting and capture of wildlife (especially for trade), land clearing for agriculture, infrastructure development and other causes of deforestation, forest degradation (e.g. through logging), and fragmentation that open new pathways along which disease can travel. Attempting to remove zoonotic threats by removing wildlife populations does not address the root cause, and may even have negative consequences that actually increase the risk of disease transmission by removing natural buffers within the intact ecosystem. So what can be done?

Drivers of risk: compromised ecosystems, wildlife trade and supply chains

Maintaining distance between human and animal activity – physical distancing – reduces the

likelihood and thereby the risk that a virus or other pathogen can 'jump' from one host to another. To reduce the risk of future pandemics, we need to evaluate and reduce or eliminate detrimental overlap between humans, their livestock and wildlife. Since ecological degradation increases the overall risk of zoonotic disease outbreaks originating from wildlife, one important strategy is to reduce human encroachment by protecting highly intact ecosystems. Another one pertains to commercial wildlife markets for human consumption (food and medicine) and associated trade.

The pandemic risk of commercial wildlife markets was already recognised during the 2002-2003 SARS outbreak. Unfortunately, policy-makers failed to let this insight guide necessary changes. While almost all human coronaviruses are believed to have zoonotic origins or otherwise circulate in animals, wildlife trade is suspected to have created the conditions necessary for the SARS Coronavirus 1 and 2 (the latter causing COVID-19) spill-over and emergence in humans. The wildlife supply chain (including illegal and legal, sustainable and unsustainable, wild-caught and captive bred sources) involves conditions conducive to the emergence of zoonotic pathogens with pandemic potential. Stress in the animals (such as from cramped conditions, transport methods, mixing with other animals, etc.) increases expulsion and release of viruses and other pathogens, while the mixing of varied species of wildlife with domestic animals and slaughtering and butchering of fresh carcasses in crowded urban markets creates an optimal environment for viruses to exchange genetic material, pathogen transmission and spread. Furthermore, recent research suggests that, as wildlife moves along the wildlife supply chain, from capture sites to large markets, and on to restaurants, the likelihood of a positive coronavirus test result increases with each step from capture to consumption. Thus, each stage in the wildlife trade chain amplifies the chance of pathogen spill-over and novel viral emergence.

Considering the high numbers of everyday human-wildlife contact, spill-over events where a pathogen, such as a virus, jumps from a non-human animal species to a human are relatively rare (although the vast majority go unnoticed and are therefore underreported). Nonetheless, it's a numbers game: the more opportunities created, the higher the chance of a spill-over occurring. This is exemplified by the increasing frequency of emerging infectious diseases stemming from wildlife, which reflects ever-growing contact points between human activity and wildlife habitat. And we now see that even a rare event, such as the virus causing COVID-19 or HIV/AIDS, can cause massive death, suffering, and devastation. While recognising that these events are rare, this must not preclude action. This increasing trend of spill-over events must be halted and reversed. We must work to lower the probability of these spill-over events as far as possible.

Context matters

There are stark geographic and context-specific differences when it comes to the pandemic risks and opportunities for mitigation. Evidence suggests that when there is a greater diversity of animal host species, the variety of virus types increases proportionately. This is one reason for areas with high biodiversity, such as those in forested tropical regions experiencing land-use changes, to have a higher risk of zoonotic disease emergence.

In countries with high species diversity, wildlife is often traded for meat, jewellery, curios, other products, traditional and non-traditional medicines, pets, or entertainment; for many countries, this trade is both domestic and international. There are, of course, regional differences. In some Asian countries, like China and Vietnam, where wildlife for food is predominantly a luxury item, governments are already moving to enact and implement important legislation and regulations to ban trade and consumption of wildlife (and China has already implemented laudable targeted regulations). In contrast, in Central Africa, for example, consuming bushmeat is a social norm, and there are large numbers of local people whose food security and livelihoods depend on wild meat consumption. But the majority of people in cities in Central Africa choose to consume bushmeat as a luxury item that is more expensive and does not relate to food security.

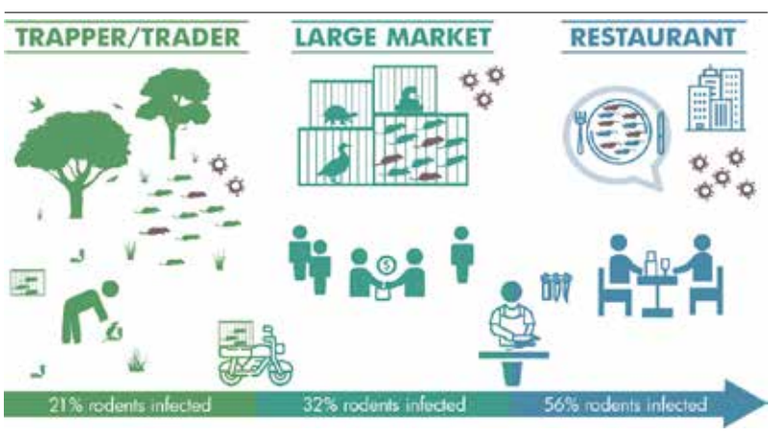
This high demand for luxury bushmeat in urban areas and wildlife trade encourages rural populations to hunt more animals than is necessary for their own consumption, thereby putting these communities at an added risk of zoonotic disease transmission and depleting resources for Indigenous Peoples and local communities (IPLCs) who rely on wild meat to meet their nutritional requirements. Policy change must be accompanied by a sustained and targeted effort to alter deep-rooted consumption practices and secure public support while respecting the rights and needs of IPLCs. This will, on a country by country basis, require certain adjustments to support existing cultural practices, formulate policy and enact appropriate legislation.

It is particularly important to ensure that private sector logging, mining, and plantation companies do not use the market closures to abrogate the legitimate rights of IPLCs who still depend on wildlife as a vital source of food, income and cultural identity, and whose effective, multi-generational stewardship has maintained most of the planet's remaining ecologically intact ecosystems. Nevertheless, recognising and ensuring the needs and rights of IPLCs should never be used as a smokescreen to facilitate continuation of commercial trade and markets that pose an unacceptable pandemic risk on a global scale. Action, albeit in a domestic context, must be taken everywhere to reduce the chance of another zoonotic pandemic.

A One Health approach to mitigate epidemic/ pandemic risks

An integrated One Health approach, which fully acknowledges the interconnectedness and interdependence of human, animal, plant, and environmental health, as outlined in the "Berlin Principles on One Health", adopted in 2019, is paramount in tackling some of the most pressing global health challenges,

AMPLIFICATION OF CORONAVIRUS INFECTION ALONG THE WILDLIFE SUPPLY CHAIN



including the potential for future pandemics. The Berlin Principles update the "Manhattan Principles" from 2004, in which the term One Health was first coined for a broader public. These principles are an urgent Call to Action for cooperative, multilateral and engaged democratic efforts at all levels of society, in every country, and at international level.

By fully acknowledging the interconnectedness and interdependence of human, animal and ecosystem health, we can identify and implement pertinent and long overdue measures to reduce the risk of future pandemics (see boxed text). Additionally, many of the measures with this aim simultaneously help to mitigate some of the other major public health challenges of our time posed by the climate and biodiversity crises, which presents us with the rare opportunity to be in a triple-win position.

A bushmeat market in Africa. Photo: Theodore Trefon

Recent analyses suggest that the cost of preventing further pandemics over the next decade by protecting wildlife and ecosystems would equate to just two per cent of the estimated financial damage caused thus far by COVID-19. The profits – legal and illegal – that are generated from the commercial trade in wildlife are negligible in comparison to the tens of trillions of dollars of economic devastation that we are now witnessing, and are even more negligible when limited to wildlife trade and markets for human consumption.

Currently expedited production of drugs and vaccines in response to the COVID-19 pandemic is a point of pride for some governments. If we are lucky and one of these products actually does prove efficacious and safe, and can be rapidly produced at scale, it will still have taken over a year to reach people with millions of deaths and terrible suffering in the interim. Large parts of the global health community are now calling for improved pandemic preparedness, e.g. through global collaboration initiatives, such as the ACT (Access to COVID-19 Tools) Accelerator, to escalate development, production and equitable access to pandemic disease tests, treatments and vaccines.

Of course, pandemic preparedness and response are very important. However, there are many challenges, some of which relate to the limitations and uncertainties of developing drugs and vaccines themselves. For some diseases, it took decades, while for others, vaccines and cures have yet to be found. Other hurdles include political challenges, e.g. the 2018-19 Ebola epidemic in Kivu, in the Democratic Republic of the Congo, became the second-largest Ebola outbreak in recorded history despite advanced containment measures, including widespread distribution of an effective vaccine, due to political instability within the affected region.

Moreover, drugs and vaccines cannot protect people from the spread of misinformation that undermines compliance with public health recommendations. Furthermore, not all epidemics and pandemics come in the immediately tangible form of a respiratory disease or haemorrhagic fever. The HIV/AIDS pandemic went unnoticed for decades, and it took further decades before an effective treatment could be developed. To this day, there is no vaccine against HIV, and according to UNAIDS, approximately 75.7 million people have become infected with HIV, 32.7 million of whom have died from AIDS-related illnesses since the start of the epidemic.

Therefore, we must not allow preparedness measures to create a false sense of security. Rather, prevention of disease emergence must be paramount. The human and financial costs associated with global pandemics will always be significantly greater than the price of measures to prevent them in the first place. Effective prevention is our greatest form of protection.

How to decrease the risk of zoonotic disease transmission

Preventing future pandemics requires a concerted effort to reconsider our interactions with our environment and to take important measures to reduce spill-over risks. The Wildlife Conservation Society supports a multipronged One Health strategy to lower the risk of zoonotic disease transmission, which should include:

1) preventing the degradation of ecosystems to preserve ecological integrity;

2) ending rural-urban supply and urban sale of bird and mammal species as wild meat;

3) ending urban demand for bushmeat;

4) reducing the risk of wildlife-to-hunter disease transmission in rural areas;

5) expanding early warning systems for emerging zoonotic diseases at the human, wildlife and forest (/habitat) interface; and

6) improving preparedness through strengthening public health infrastructure and outreach to protect the health of Indigenous Peoples and local communities.

Kim Grützmacher is currently Program Manager in the Health Program of the Wildlife Conservation Society (WCS). She is a veterinarian and holds a PhD in Biomedical Sciences which she obtained through her research in Germany's Robert Koch Institute's former junior research group "emerging zoonoses".

Dr Chris Walzer is Executive Director of Health at the Wildlife Conservation Society. He is a board-certified wildlife veterinarian and professor of Conservation Medicine at the University of Veterinary Medicine in Vienna, Austria.

Dr Susan Lieberman is currently Vice President, International Policy with the Wildlife Conservation Society. She holds a PhD in tropical ecology from the University of Southern California, and has worked at the interface of conservation science and intergovernmental policy for more than 30 years.

Dr Amanda Fine is the Associate Director of Health at the Wildlife Conservation Society and oversees WCS health initiatives in Asia. She is a veterinarian with a PhD in epidemiology and has over 20 years of experience working at the intersection of wildlife, human and livestock health.

Contact: kgruetzmacher@wcs.org

Wilson Yoeza is a 73-year-old indigenous weather forecaster from Bangalala, Same district of Tanzania. He uses traditional methods to derive his forecasts, including the observation of environmental cues from particular insects and trees.

Photo: Thomas Omondi/ IDRC

Uniting One Health and food systems for a more sustainable and inclusive world

Food systems exemplify the complex interdependencies between humans, our physical environment and other organisms. Changes to our food system, both as short-term shocks or long-term trends, have direct impacts on human, animal and environmental health. Linking food systems and One Health approaches closer together in research is a significant area of opportunity to enhance sustainability and inclusiveness.

By Dominique Charron and Evelyn Baraké

Thanks to the COVID-19 pandemic, zoonotic disease epidemics are currently among the most high-profile public health issues. The story of this pandemic cannot be told without reference to food systems, and food markets in particular. But COVID-19 is far from being the only zoonotic disease whose story arises in food systems.

Take Chagas, a disease endemic in 21 Latin American countries and affecting six to seven million people world-wide. Transmitted by the triatomine or kissing bug, it is generally considered a vector-borne disease closely associated with poverty. People become infected by scratching a bite from an infected triatomine bug, which spreads the bug's fecal matter into the bite wound. But the ecology of Chagas is changing. Starting in the mid-2000's, a growing number of acute Chagas cases were reported in the Amazon basin, killing dozens and affecting hundreds of people. The outbreaks in the Amazon were notable in part because they were evidence that Chagas had found a new mode of transmission: food. In most of these new cases, people had become infected through eating food contaminated by infected triatomines or their feces rather than through bites.

While a One Health approach can help elucidate the evolving mechanics of the transmission of Chagas disease – from insects, to animals and to fruits, to humans – the full story requires an understanding of food systems. Slash and burn agriculture, a common prac-

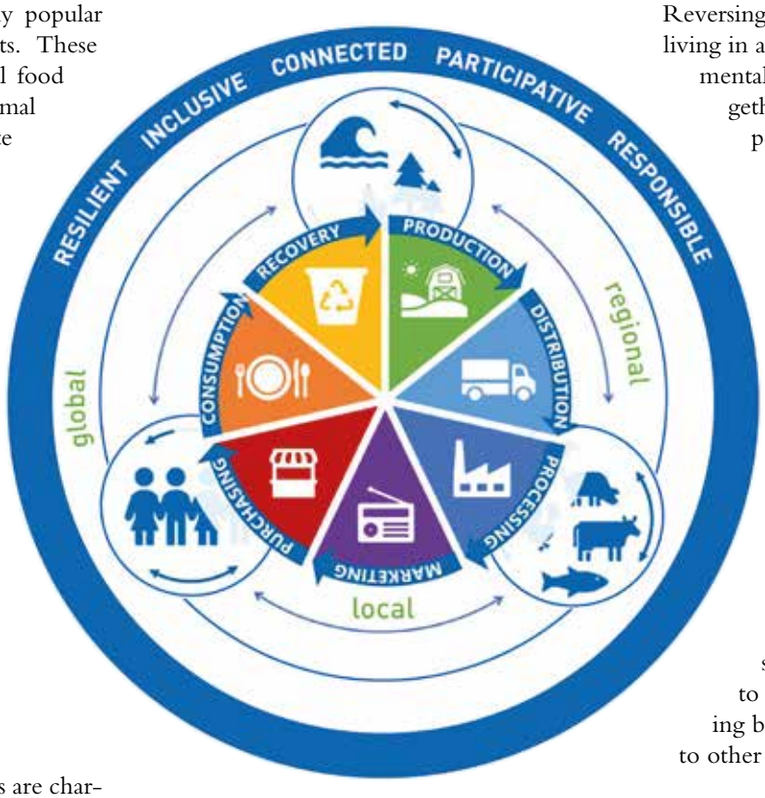
tice used to open up more land in the Amazon forest for cultivation, created the perfect habitat for the triatomine bug. Concurrently, açai berries grown from certain palms in the area were becoming an increasingly popular commodity in global food markets. These economic pressures from the global food system intersected with human, animal and environmental health to create ideal conditions for the proliferation of acute Chagas.

The story of Chagas illustrates how the threat and spread of zoonoses are best understood by combining a One Health approach with knowledge of food systems. The challenge is that food systems are largely missing in the field of One Health, and vice versa, food systems research could do more to integrate the strengths of a One Health approach.

What's in a food system, anyway?

Much like One Health, food systems are characterised by complex interdependencies between multiple actors. This includes all the interlinked actors in the supply and value chains for food products, from the production stage through to processing, packaging, distribution, consumption and waste management. Food systems also include the broader economic, societal and natural environment that supports them.

Sustainable and climate-resilient food systems are a key ingredient of achieving many of the Sustainable Development Goals (SGDs), including zero hunger, good health and well-being, responsible consumption and production, climate action, life below water and life on land. Sustainable food systems deliver food security and nutrition for all while ensuring that the production methods of today do not compromise the food security, nutrition and health of future generations. Food systems are considered resilient if they can withstand or rapidly bounce back from major shocks, such as pandemics or extreme weather events resulting from climate change.



A long way to go to achieve climate-resilient food systems

There remains considerable work to be done on food systems globally to ensure that they become sufficiently resilient and sustainable. Our food systems remain vulnerable to economic and climate shocks, recurring issues of food insecurity, and their capacity to promote healthy, sustainable and affordable food is decreasing. This has been shown most recently by the COVID-19 pandemic, which could significantly exacerbate the already rising number of hungry people world-wide. This human health and economic crisis bears the risk of halting or undoing progress on the SDGs, many of which are not on track to be achieved by 2030. Meanwhile, we must also contend with climate change, which is deepening global inequalities and affecting food production and availability, in turn affecting nutrition and global health. The links between social and environmental change are contributing to the rise in hunger and problems of access to healthy food.

Reversing these trends will be difficult. We are living in an era in which human and environmental crises are frequently occurring together in what can be described as compounding calamities. These events, many of which are accelerated by climate change, are creating additional stressors on the food system and threaten our ability to produce enough healthy food and make it accessible to all. Mitigating these compounding calamities and making up lost ground on SDGs requires strengthening the resilience of food systems and thinking in more integrated ways to transform food systems for the better. Knowledge and innovation can help build up the equity, diversity and sustainability of food systems and increase their resilience to climate change while also promoting better health, nutrition and resilience to other shocks, pandemics included.

Knowledge of food systems can enrich One Health, too

The other side of the coin is that food systems research has a lot to offer the One Health approach. High-profile issues that require a One Health approach, namely zoonotic diseases and antimicrobial resistance (AMR), are challenges that arise in food systems and, ultimately, affect them as well. A One Health approach anchored in an understanding of food systems is needed to develop primary prevention methods.

Consider this: an estimated one billion farmers world-wide depend on livestock for their livelihoods, their nutrition and as a form of household insurance. Women who own and are responsible for caring for their household's livestock face a particular set of challenges due to restrictive gender norms and persistent inequalities. For them, livestock can be an important source of employment and financial security. The livelihoods of these populations are therefore based on living in close proximity to livestock. Depending on the setting, these livestock smallholders or their animals may also be in close contact with local wildlife. These factors put them at increased risk of zoonotic diseases. Since livestock smallholders generally

LOST GROUND ON SDG 2: NO HUNGER

After a decade of improvement in the rate of world-wide undernourishment, progress halted and faltered starting in 2014. The prevalence of undernourishment has increased since 2014 and extends to 2019. Today, there are 60 million more undernourished people than there were in 2014. Between 2018 and 2019 alone, the number of undernourished people increased by 10 million.

operate in resource-poor settings, measures to reduce disease outbreaks, such as vaccines or cull-and-compensate, are hard to access and implement. Tackling the risk of zoonotic pandemics requires a deep understanding of these interactions as well as the socio-economic and cultural contexts in which they take place.

World-wide, livestock production is also contributing to the emergence of AMR. In the food industry, it is common for antibiotics to be overly used on healthy livestock and fish to promote growth and prevent disease. This is creating environments that hasten the natural process by which microorganisms develop defences to these threats and become resistant to treatment. Alarmingly, the emergence of multi-drug-resistant bacteria, so-called "superbugs", threatens to usher in a future where the simplest medical procedure can lead to devastating complications as a result of untreatable infections.

The full scope of the problem, especially in low- and middle-income countries, is unclear, and monitoring and tracking systems are lacking. But there is strong evidence that this is a global problem, whose spread into low- and middle-income countries is facilitated by intensive animal production systems that are proliferating to meet the rising global demand for animal protein. Global AMR hotspots have been identified across the Global South, notably in India, China, Pakistan, Iran, Turkey, Brazil, Egypt and Vietnam, and in the areas surrounding Mexico City and Johannesburg. Addressing antimicrobial resistance requires global, coordinated, multilateral efforts grounded in a One Health approach to reduce the misuse of antimicrobials. Part of this push will involve supporting research to better understand how our food systems contribute to and are affected by AMR and to develop alternatives that will work for food producers across the globe.

The way forward

Crises like COVID-19 expose the vulnerabilities in the food and health systems of many countries. Most often, it is resource-poor people living in difficult environments, including environments that are highly impacted by climate change, who are on the front lines. Investing in research for climate-resilient food systems can enhance global health, livelihoods and food security today and for future generations. The One Health framework can significantly contribute to advancing research and innovation towards this goal. Reciprocally, bringing a stronger dose of food systems expertise into One Health research will provide valuable insights when addressing the threat of AMR and zoonotic disease epidemics arising in food systems. COVID-19 has jolted us all to think more about resilience – our own, that of our health systems and that of our food systems. Linking these two powerful concepts and fields of research, we can act to turn the negative SDG trends around and build practical, more resilient, healthy, nutritious and sustainable food systems that work for everyone.

COMPOUNDING CALAMITIES IN EAST AFRICA

In 2020, areas of East Africa experienced a rapid-succession series of severe health and environmental crises: COVID-19, devastating floods and the worst infestation of desert locusts in over 25 years. These events each impacted local food systems and compounded one another, increasing the vulnerability of local populations and reducing their ability to engage in social distancing and to practise basic hygiene measures. The same weather conditions that contributed to the locust infestations also affected crop growth and food prices. Food supplies diminished by the locust pest were further diminished by flooding, deepening local food insecurity.

In 2020, East Africa experienced the worst infestation of desert locusts in over 25 years.

Photo: Sven Torfinn/ FAO

Dominique Charron is Vice-President, Programs and Partnerships at Canada's International Development Research Centre (IDRC). She holds a PhD in epidemiology and a Doctor of Veterinary Medicine from the University of Guelph, Ontario, Canada.

Evelyn Baraké is a Program Officer working in knowledge translation at Canada's International Development Research Centre (IDRC).
Contact: ebarake@idrc.ca

TACKLING RIFT VALLEY FEVER EPIDEMICS IN FOOD SYSTEMS

In 2018, the World Health Organization named Rift Valley Fever (RVF) one of the world's eight most threatening pathogens. This viral disease is endemic in Eastern Africa and the Horn of Africa region and affects goats, sheep, cattle and humans. Its outbreaks occur in irregular 5 to 15 years cycles. This disease poses a significant risk to human health and threatens the economic and food security of smallholder farmers in these regions. Although there is a vaccine against RVF, its uptake among smallholder farmers is limited because it is expensive and the incentive to vaccinate livestock during the long periods between outbreaks is low. Tackling this zoonotic threat requires working closely with smallholder farmers to develop solutions that consider the obstacles to vaccine uptake.
This is one of the diseases targeted by the Livestock Vaccine Innovation Fund (LVIF), a 57 million Canadian Dollar initiative supported by the Bill & Melinda Gates Foundation, Global Affairs Canada and the International Development Research Centre (IDRC) for the development, production and commercialisation of vaccines against neglected livestock and zoonotic diseases in sub-Saharan Africa and South and Southeast Asia. One of the LVIF projects is working to combine the RVF vaccine with other livestock vaccines that farmers routinely use to reduce these barriers to uptake.

We still remain too much in the academic area

At the 6th World One Health Congress, scientists and representatives of governmental and non-governmental organisations gave accounts of their activities at the animal-human-environment interface. Alongside the "usual suspects", topics were on the agenda that showed just how comprehensive and universally applicable the One Health approach is.

This year's World One Health Congress, co-organised by the One Health Platform, the University of Edinburgh/Scotland and the SACIDS (Southern African Centre for Infectious Disease Surveillance) Foundation for One Health, was held under the motto 'Advancing science to improve health and security'. The exclusively virtual event was devoted to five major thematic blocks: One Health science, antimicrobial resistance, the science policy interface, SARS-CoV-2 and, as a cross-cutting topic, global health security. The variety of topics was reflected in roughly 250 lectures. The following is a small selection of them.

What about antimicrobial resistance in LMICs?

Antimicrobial resistance (AMR) is among the top health concerns world-wide. However, in low- and middle-income countries (LMICs), trends in antimicrobial resistance are poorly documented, and surveillance networks are still in their infancy. Thomas P. Van Boeckel of the Swiss Federal Institute for Technology (ETH) in Zürich, Switzerland, presented a research project in which twelve thousand resistance rates had been extracted from point prevalence surveys (point prevalence refers to the number of diseased individuals at a certain point in time) in LMICs on common foodborne pathogens. For this purpose, data on antimicrobial resistance for *Escherichia coli*, non-Typhoidal *Salmonella*, *Campylobacter* spp. and *Staphylococcus aureus* was used. Resistance rates were curated across all the studies in a public database (resistancebank.org). For each study, the proportion of drugs tested with resistance levels higher than 50 per cent were calculated. Based on this, Van Boeckel and his colleagues then compiled maps at 10 km resolution with the aid of geospatial modelling.

An evaluation of the data revealed that from 2000 to 2018, the proportion of antimicrobials with resistance higher than 50 per cent increased twofold in chickens, and threefold in pigs in the countries surveyed. Considerable geographical discrepancies became apparent. While China, Northeast and South India represent the largest hotspots of resistance, new hotspots are emerging in Central India, Brazil, and Kenya. "Our maps suggest that world-wide, a substantial proportion of chicken, cattle and pigs are raised in hotspots of antimicrobial resistance," said Van Boeckel, summarising the results of the survey. The global maps are to provide a baseline to outline priorities for interventions in low- and middle-income countries and monitor their efficacy in the future.

Mind the (gender) gap!

Linda Waldman of the Institute of Development Studies at the University of Sussex, United Kingdom, pointed to the need for gendered approaches to antimicrobial resistance. Waldman presented findings from a case study piloting the Community Dialogue Approach (CDA) for addressing AMR in Comilla district, Bangladesh. Fifty-five community-based volunteers from five community clinics were trained in antibiotic usage, communication and facilitation skills. Subsequently, these volunteers hosted 400 meetings during which community members explored specific health issues affecting communities, identified solutions and decided how communities might address these issues. Not only did the necessity of training female and male facilitators to conduct community dialogues with female and male groups respectively become apparent in the course of the study. Differences in handling antibiotics were also revealed. Women

In low- and middle-income countries, legislation on pesticide use tends to be feeble.

Photo: Jörg Böthling

typically attend local community clinics where health care practitioners have been trained on the appropriate use of antibiotics. The latter pass on this knowledge to the women, who are responsible for family health. In contrast, men typically purchase antibiotics from pharmacies without prescription and administer drugs to livestock. "Attention must focus on how men and women, and the power relations between them, inform livestock production, health and livelihoods in ways that have significant ramifications for AMR," Waldman concluded.

Snakebite – the underestimated neglected tropical disease

"Snakebite envenoming is a neglected tropical disease with a substantial public health impact. Poor rural communities are particularly affected," explained Sara Babo Martins of the Faculty of Medicine at the University of Geneva, Switzerland, introducing her research. The world-wide number of envenomed people yearly is put at 1.8-2.7 million, while, 81,000 to 138,000 victims die yearly and 400,000 are permanently disabled. What is less known is that various types of domestic animals are affected by venomous snakes, with high case fatality rates in livestock. "This double socio-economic impact has not been yet assessed and can only be captured by using a One Health lens," the scientist said. For this purpose, in the framework of a nation-wide multi-cluster random survey, she interviewed 11,700 households in Cameroon and just below 13,800 households in Nepal regarding the impacts of dry bites. The questionnaires established data jointly on human health (such as death, stress, wound-care, amputation, blindness, impairments of legs, feet, arms and hands, serum sickness) and animal health (mortality/morbidity) as well as on out-of-pocket expenditure in healthcare and animal healthcare and on productivity losses.

In both countries, high annual incidence and mortality rates in humans were reported. The conspicuously high mortality rate among 5-14-year-olds – it was 16 times higher than expected – and the extensive impacts on rural livelihoods surprised the scientist. In Nepal, for example, 28 per cent of respondents stated that they had to stop working owing to snakebite; 40 per cent said that a household member had had to stop working. In order to estimate the health burden and economic impact in the two countries, disability-adjusted life-years (DALYs) and cost-of-illness assessments were performed (DALYs measure the disease burden by referring to the number of years of ill-health, disability or early death). Regarding Nepal, the studies recorded 2.7 million US dollars in livelihood losses per year and 241.102 DALY/year.

Public health and plant health intrinsically linked

Although human and animal health were directly or indirectly dependent on plant health, the latter was typically not integrated in the discussion of one health, criticised David Rizzo of the College of Agricultural and Environmental Science at the University of California, Davis, USA. He reminded the meeting that foodborne illnesses pose a serious global burden on human health, affecting 600 million people or 33 million Disability Adjusted Life Years in a single year. In the context of One Health, plant health impacted on four areas: food security, food safety, economics and ecosystem health.

One example is bananas, which represent an important staple crop for millions of people in low-income countries, providing them with carbohydrates, vitamins and protein. In addition, they help prevent soil erosion, offer other crops shade, supply animal feed and serve as a raw material in manufacturing utensils such as baskets, carpets, shoes and many more. In East Uganda, there was a severe outbreak of banana wilt in 2001 which had been caused by the bacterial pathogen *Xanthomonas campestris pv. musacearum*. Infestation destroyed at least a quarter of the harvest, almost doubling the price of the crop. As a result, household eating habits changed owing to fewer meals, smaller meals and substitutes, with negative impacts on nutrition and health.

Rizzo demonstrated the link between plant health, food safety and public health by referring to lessons learnt through the outbreak of aflatoxicosis in Kenya. One of the effects that ingestion of aflatoxines caused by the fungus *Aspergillus flavus* via crops and stored grains leads to is acute liver and kidney disease, as a case study from Kenya carried out in 2004/2005 shows. A total of 125 people died of aflatoxicosis triggered by eating home-grown maize. Chronic exposure may lead to liver cancer and immune suppression and is a threat to humans and animals. Five billion people in low- and middle-income countries were at risk of chronic exposure to aflatoxins. "It's time to face the fungal threat," the scientist warned, adding however that the countries affected often lacked the necessary infrastructure.

And last but not least, high levels of pesticide use in plant-based agriculture impact negatively on public health. Chronic exposure owing to the application of agents or their residues in plants or drinking water may lead to depression and neurodegenerative disease in adults and neuro-developmental toxicity in children. Whereas the use of pesticides in high-income countries is strictly regulated, legislation in LMICs often tends to be feeble. Training of farmers in the safe handling of plant protection agents and integrated pest management ought to be part of a One Health approach covering the entire complex value chain – from cultivation through harvest, food processing and distribution to food access.

Do not neglect the social dimension

New insights into the epidemiology of both neglected tropical diseases and newly emerging infections, successes achieved in vaccine development and new strategies in diagnostics and detection, and the prospects offered by big data and artificial intelligence for surveillance, early warning systems and intervention strategies – despite the enormous significance of "technical advancements" which One Health research can boast, what really counts in putting the One Health approach on a broader base again and again became apparent in the discussions during the five-day event: political will and financial backing. Above all, the social dimension of One Health had to remain in focus, said Jakob Zinsstag of the Swiss Tropical and Public Health Institute (Swiss TPH) in Basel. And this required engaging with the social, economic and value systems that drive health processes. One Health meant far more than the absence of disease. It had to be understood as a complex set of relationships, trade-offs and compromises. This had once again been highlighted by the impacts of the current corona pandemic on people's livelihoods. A participatory, trans-disciplinary and cooperative approach was key. "Although we scientists believe that we have the knowledge and we can explain the situation, we must engage with communities and authorities when it comes to finding the much needed locally adapted solutions. This can often not be decided at an academic desk," Zinsstag maintained. In other words, it is time to reach beyond the academic area.

Silvia Richter

More information: **worldonehealthcongress.org**

Photo: Author

Jonathan Mockshell is Agricultural Economist at the Alliance Bioversity International and International Center for Tropical Agriculture (CIAT) in Cali, Colombia and associate research fellow at the German Development Institute (DIE) in Bonn, Germany.
Contact: J.Mockshell@cgiar.org

Photo: Uni Hohenheim/ Jan Winkler

Regina Birner is Professor at the Hans-Ruthenberg-Institute of Agricultural Sciences in the Tropics of the University of Hohenheim, Germany.
Contact: Regina.Birner@uni-hohenheim.de

Reconciling perspectives to find solutions

There is a longstanding debate among agricultural development stakeholders: state-led versus market-led strategies to transform food systems. While narratives provide an important framework to better understand this policy dichotomy and the choices of decision-makers, they are often neglected in food systems policy-making processes. Our authors recommend making use of policy narratives to find a way to solve real-world problems.

By Jonathan Mockshell and Regina Birner

Disruptions from the COVID-19 pandemic, desert locust swarms and looming food security crises are creating a renewed sense of urgency among scientists, decision-makers, the private sector, civil society and development organisations to fix broken food systems. The upcoming United Nations Food Systems Summit in 2021 presents an opportunity to harness this momentum for tackling the challenges affecting global food systems and chart a course forward. To do so effectively, stakeholders must address the longstanding debate over the policy instruments needed to transform the agricultural sector.

For years, food system stakeholders have deliberated over questions such as: What role should governments play? Are input subsidy programmes an effective strategy to increase agricultural productivity? What are the merits of agroecology versus sustainable agricultural intensification or blended sustainability? Do small-scale farms have development potential, or is supporting them "romantic populism"? Disagreement over these points and the ensuing divergent narratives have led to fragmented initiatives and policy choices that do not offer adequate solutions to the situations at hand.

Given the current confluence of crises facing global food systems, we must look to bridge these differences by developing a reconciling perspective to real-world problems.

Agricultural development dichotomies: state versus market-led

While development dichotomies are not new, pressure is mounting to resolve the policy impasse they create. For decades, fundamental divisions in ideas and beliefs have been observed among development economists. These differences have been described by Paul Streeten as "development dichotomies". Streeten highlighted the fundamental divisions in ideas and beliefs that he observed among development economists. For example, there is the division between those who believe "bigger is better" and those who advocate "small is beautiful".

Such dichotomies exist within agricultural development as well. In particular, there is a divide between those who put their faith in state-led approaches and those who favour market-led approaches to promoting agricultural development. In our recent paper published by *World Development*, we identify two food systems coalitions with divergent policy narratives: the agricultural support critique coalition and the agricultural support coalition.

Analysis of the two coalitions reveals distinct and oppositional narratives. While the agricultural support critique coalition demonstrates a preference for market-oriented fertiliser policy reforms, the agricultural support coalition emphasises the need for strong government support, especially by providing input subsidies. The former coalition, in addition to promoting a market-based approach, also back a second narrative against agricultural subsidies. They emphasise that the prevailing government input subsidy programmes are ineffective and inefficient and stress the need for the private sector to lead investment, arguing that public sector finance crowds out private sector investment. In Senegal, Ghana, and Uganda, these arguments can be seen in policy actors' statements such as "Subsidies are an expensive component of the government budget", "There is lack of transparency regarding the fertiliser and seed input subsidy distribution", "Subsidies crowd out private investment", and "Subsidies are politically efficient but not economically efficient".

In contrast, the agricultural support coalition position themselves as advocates of farmers' welfare in setting policy priorities. The agricultural support actors frame their narratives (ideas and policy beliefs) in the context of wider national and global debates on agricultural modernisation (e.g. irrigation infrastructure and farm mechanisation), job creation, and

food sovereignty. Policy concerns regarding agricultural productivity problems are captured in food and nutrition security narratives to provide a justification for government-oriented subsidy programmes. Within this coalition, the use of tractors and other modern inputs (e.g. seeds, fertiliser, irrigation, tractor services, etc.) is indispensable in moving smallholders out of their current "hoe and cutlass" nature of farming, a metaphor they use for "traditional" or "old" farming systems.

So, who has the better story?

The narrative analysis of the two advocacy coalitions exposes their contrasting argumentative strategies. However, the coalitions share common ground on the view that low agricultural productivity is the major problem facing the agricultural sector. Utilising this problem as the argument's premise makes for a stronger case in support of government subsidies because it is well established in the agricultural economics literature that market failures are widespread in agriculture and contribute to the problem of low productivity. Therefore, the agricultural support coalition are able to construct a more straightforward narrative. They present a range of stories that explain why government support is necessary and how much support will address the problems of low agricultural productivity. The support coalition's narratives can be summarised as follows: "Productivity is low due to limited access of smallholders to inputs and lack of guaranteed prices. The proposed policy instruments (block farming, fertiliser and tractor subsidies, and price stabilisation through buffer stocks) are essential to address these problems, and hence productivity will be increased. Agriculture will become more attractive to the youth and serve as an engine of growth."

In contrast, the coalition that promotes market-based approaches formulates the majority of its critiques on government subsidies and lacks clear-cut narratives that tell a better story. Rather than presenting a convincing alternative, the critique coalition focuses on explaining why government support strategies are difficult (governance problems, political capture) and why they will not be successful. While the agricultural support coalition seem to have a "better story" as far as the structure of their narrative is concerned, this does not imply that their story is better in a normative sense, that the prescribed policies are indeed better suited to reach their intended goals than the policies suggested by the agricultural support critique coalition.

Agricultural productivity problems are frequently referred to in food and nutrition security narratives to provide a justification for government-oriented subsidy programmes. Photo: Solomon Kilungu/ CCAFS

Developing a reconciling perspective

The dichotomous perspectives regarding solutions to low agricultural productivity and sustainable agriculture, which is crucial for economic development in Africa, has led to a policy deadlock: decision-makers continue to implement input subsidy programmes that have only limited effects in increasing agricultural productivity but are supported by a strong narrative.

As disruptions caused by the COVID-19 pandemic are progressing and likely to have further impacts on the food systems, it is more urgent than ever to bridge the prevailing divergent perspectives and make meaningful progress towards achieving the Sustainable Development Goals. We need to develop a reconciling perspective on this real-world problem.

Meta-narratives are an underexplored solution to bridging the two narrative worlds. One such concept that had the potential of a meta-narrative is market-smart subsidies. The term refers to temporary subsidies that are designed to promote, rather than undermine, the development of input markets (e.g. using fertiliser vouchers), as defined in a study led by Michael Morris. The concept had potential because it contained elements of both the agricultural support coalition and the agricultural support critique coalition. However, the study led by Morris did not develop a straightforward narrative to promote market-smart subsidies. Rather, they are portrayed as an option that "may be justifiable on a temporary basis".

Additionally, although market-smart subsidy schemes have, indeed, been implemented in several African countries, a recent review led by Thom Jayne found that such subsidies had only a limited effect on productivity, partly because the market-smart principles were "watered down or overturned during implementation".

Thus, it appears that neither of the two coalitions fully embraced market-smart subsidies, and they did not become the basis of a powerful meta-narrative that could promote policy-oriented learning across coalitions and other food systems stakeholders. While a successful meta-narrative has not arisen out of market-smart subsidies, other opportunities for reconciliation may present themselves. Paying more attention to the narrative foundations of development dichotomies can help overcome deadlock among agricultural policy stakeholders and clear the path forward towards sustainable, resilient global food systems and improved food security.

The research was part of the multi-country project "Promoting Participatory and Evidence-Based Agricultural Policy Processes in Africa" run by the International Food Policy Research Institute (IFPRI) and funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and with further support from the CGIAR Research Program on Policies, Institutions, and Markets (PIM) led by IFPRI.

References: **www.rural21.com**

Simple solutions to complex problems

In 2015, the government of the Indian state of Andhra Pradesh launched the "Andhra Pradesh Community-managed Natural Farming" programme. The idea was to make farming climate-resilient and thus attractive again for young people. The recipe for this is mimicking processes in nature.

By Vijay Kumar Thallam and Swati Renduchintala

The year 2020 has offered us a glimpse of a future that is inevitable if business as usual continues. The COVID-19 pandemic and the subsequent lockdown in India have brought to forefront the cracks that were already persistent but mopped from sight. The collapse of the food systems across the world during this time shows the vulnerability of humankind not just to zoonotic viruses but also to the impending climate change crisis, which would further aggravate the current situation. The worst sufferers of these crises would be low- and middle-income countries, as their economies rely majorly on climate-based livelihoods and natural resources. In the context of countries like India, climate injustice looms greatest for children, the small landholding farmers, rural women and tribal (indigenous) communities, pushing them to further marginalisation.

The web of complex problems – farmers' livelihoods, human health and environment crisis

It is an accepted truth that farmers' distress is very acute and is increasing each year. The conventional agriculture practices have induced the farmer to rely heavily on synthetic fertilisers and pesticides, leading to higher dosages and higher annual costs. Extreme weather events like prolonged dry spells, unseasonal rains and floods have increased the risks of crop failures. The market uncertainties are adding to farmers' problems. All these factors are pushing farmers into a continual state of distress and a perpetual cycle of debt. This is also leading to distress migration of young farmers and farmworkers to urban areas.

At the same time, there are serious problems regarding the supply of food and its safety and quality. By 2050, the global population is expected to reach 9.7 billion. Food supplies are likely to be under far greater stress, and large populations are expected to face food scarcity. The existing practices of conventional agriculture are leaving chemical residues in the food. These practices have also led to severe

A farmer preparing jeevamrutham, a liquid inoculant made of cow dung, cow urine, jaggery, basin powder and topsoil.

Photos: RySS

Ground covered with mulch.

Abundant earthworm population = healthy soil.

A birdnest in a natural farming field.

reductions of nutrient density in the food. The COVID-19 pandemic has revealed the fragility of the immune system in a large number of people. The lack of nutrients in the food is one of the major factors in reduced immunity levels.

The current crop production and land management practices are resulting in continuous losses of soil organic matter. This in turn has led to a soil, water and biodiversity emergency. It has been estimated that world-wide, 40 to 60 per cent of soil organic matter is already lost, and with the current rate of degradation, topsoil will be completely depleted within the next 60 years. The use of synthetic chemicals in agriculture reduces the soil biology, which is so vital to creating soil organic matter. The chemical agriculture practices also contaminate groundwater and other water-dependent ecosystems, leading to biodiversity losses in the farmland. Prevailing agricultural practices such as mono-cropping are contributing to loss of crop biodiversity, and the use of chemical pesticides is causing huge losses in biodiversity of insects. Global warming is exacerbating all the above effects.

The biggest tragedy is that the current crop production and land management systems are themselves a very significant cause of global warming. So while the food system is seriously impacted by climate change, ironically, the present food system is one of the biggest factors causing climate change.

Andhra Pradesh is a south eastern state in India. Agriculture is its most important economic sector, employing nearly 62 per cent of the population, and contributing 28 per cent of Gross State Domestic Product (GSDP). Andhra Pradesh is also known as the Rice Bowl of India and has a diversified cropping system covering 8 million hectares of land in cropped area, while about 1.4 million hectares is under horticulture. Andhra Pradesh is India's largest producer of fruits, eggs and aquaculture products.

Transformative solutions

It is in response to these multiple crises that the Government of Andhra Pradesh has set up the Andra Pradesh Community-managed Natural Farming (APCNF) programme. The underlying notion here is to turn to farming approaches that are in harmony with nature, as they build on ecological science, rather than on 'input economics'. By starting with, building on and improving the ecological conditions obtaining in each and every site, the concept of natural farming is showing that it is possible to reduce the need for external inputs, remove completely the need for synthetic inputs and deliver instead a form of farming that costs less, in financial and environment terms, and is more climate-resilient. It is called natural farming because it mimics the processes in nature to build healthy natural capital. This farming has been shown to have positive impacts on all the interrelated issues: farmers' livelihoods, young farmers' careers in agriculture, citizens' food, nutrition and health security, and restoration of the environment and mitigating climate change.

It safeguards our collective future by:

- reducing costs of cultivation and risks, and increasing yields. It is climate change-resilient, thereby creating fewer risks in farming. It is thus generating higher net incomes and regular incomes;
- producing more food – food which is safe, nutritious and free of chemicals;
- reducing the distress migration of youth from villages and creating reverse migration to villages;
- enhancing soil health, water conservation, regenerating coastal ecosystems and biodiversity.

The APCNF programme follows all the generic principles of regenerative agriculture (see Box on next page). Based on these principles, a wide range of practices have been developed by APCNF. Within these practices, there are a lot of variations depending on the area and the farming traditions of the communities. The not-for-profit company Ry.S.S. (Rythu Sadhikara Samstha, the Government Corporation for Farmers' Empowerment) provides a package of practices, through the farmer-led extension system. The farmers utilise them in combination with their own practices and innovations, and apply them to their fields and to crops.

A major innovation: pre-monsoon dry sowing

One of the biggest breakthroughs in the APCNF programme is drought proofing

through the pre-monsoon dry sowing (PMDS) process. This breakthrough came as a result of experiments carried out in 2018. In the 2020 season piloting phase of the PMDS practice, farmers sow between 12 and 15 different kinds of seeds in dry soils from April onwards, without waiting for the rains. Thanks to the special Natural Farming protocols developed for PMDS, farmers are able to raise crops successfully in the pre-monsoon context. This has also been acknowledged as an important breakthrough by international experts. In the current year, more than 90,000 farmers have taken it up in 70,000 acres across all the 3,011 programme villages of the state. The sowing which started in April, on dry soils, goes on until the first major rains are received and farmers take up planting of crops in June, July or August. The objective is to ensure that all farmers in the State, especially those having only rainfed lands, are able to take crops throughout the year and are not subject to the vagaries of the monsoons. Farmers in semi-arid, drought-prone districts successfully take up two or three crops in a year, where previously they could take only one crop, and only if the weather conditions were favourable.

The PMDS initiative was initiated in the drought prone semi-arid areas, but now it has been taken up in all the farming situations in the State. Farmers have experienced higher paddy yields, lower pest attacks and lower costs. Research is being conducted to understand various dimensions of this critical breakthrough.

Success factors of the scaling-up process

Our experience shows that natural farming is not only highly beneficial but is also scalable in a reasonable period, provided there is a proper strategy in place to scale it up. In four years' time, the number of farmers enrolled to practice natural farming rose from 40,000 farmers in 2016 to around 700,000 farmers and farmworkers in 2019 – a seventeen-fold increase in just four years. This is a very significant achievement. The APCNF programme has been recognised as the world's largest agroecology programme in terms of number of farmers enrolled. The target for 2020 and 2021 is 1,050,000 farmers and farmworkers – 700,000 farmers and 350,000 farm-workers respectively.

The real success of the Andhra Pradesh (AP) programme lies in the scaling-up strategy adopted, which includes the following factors:

The generic principles of regenerative agriculture

- A healthy soil microbiome is critical for optimal soil health and plant health, and hence for animal and human health.
- Photosynthesis drives soil biology. Therefore, soil should always be covered with crops (the living root principle), throughout the year, to maximise photosynthesis and thereby maximise carbon getting into the soil as the root exudates.
- The soil across a farm or larger field/collection of fields should always have diverse crops; a minimum of eight crops over the year is recommended. The greater the diversity, the better.
- Soil should not be bare, as that will starve the microbes it contains. In the months when cropping is not possible, there should at least be crop residue mulch cover.
- Minimal disturbance of soils is critical, hence no-till farming or shallow tillage is recommended.
- Animals should be incorporated into farming. Integrated farming systems are critical for promoting natural farming.
- A healthy soil microbiome is the key to retaining and enhancing soil organic matter. Bio-stimulants are necessary to catalyse this process. There are different ways of making bio-stimulants. In India, the most popular ones are based on fermentation of animal dung and urine, and uncontaminated soil.
- Increasing the amount and diversity of organic residues returned to the soil is very important. These include crop residues, cow-dung, compost, etc.
- Pest management should be done through better agronomic practices (as enshrined in Integrated Pest Management – IPM) and through botanical pesticides (only when necessary).
- Use of synthetic fertilisers and other biocides is harmful to this process of regeneration, and is not allowed.

- **Farmer-to-farmer extension system.** Best practising, champion farmers are the trainers. There is one farmer trainer per 100 farmers. This is the most critical innovation. Natural farming is knowledge-intensive and not input-intensive. Hence extension and intensive handholding plays a critical role.
- **Setting up women self-help groups (SHGs).** Women SHGs are a crucial factor in collective action, knowledge dissemination, supporting each other during transition, financing members to purchase the inputs required for natural farming, and monitoring and managing the programme.
- **Long-term handholding support to each farmer.** A farmer typically requires three to five years to make the transition. The AP project provides support to the farmer for this long duration, through the farmer-to-farmer extension system and the network of SHGs. Since the trainers are themselves practising farmers, their credibility is very high, and they are able to motivate other farmers to change.
- **Whole village approach.** In AP, the objective is to convert all the farmers in a village into natural farming practitioners. APCNF has targeted all small and marginal farmers and tenant farmers in the village, who constitute more than 85 per cent of farmers. It takes five to six years to change all the farmers in a village. Through the extensive network of SHGs, built over two decades, APCNF is able to reach out to all small and marginal farmers and tenant farmers in the village. Seeing these farmers reaping the benefits of natural farming, the remaining farmers are also opting for it.
- The **support of the Agriculture Department** in the transition process has been very positive, and this is a really important factor for the success of the programme.
- **Government investments** in Andhra Pradesh are for capacity building, knowledge dissemination and long-term handholding. It is estimated that it costs around 340 US dollars per farmer, and over six years of time to transform 80 per cent of the farmers in a village to natural farming.
- **Building strong evidence in favour of natural farming is critical.** Several studies have been initiated by reputed national and international institutions.

Scientific evidence

The APCNF programme accords highest priority to scientific evidence. The programme

Adaribariki Seethamma is a lead natural farmer living in the Pedalabudu village of Araku Mandal in Visakhapatnam district. Of her total land of one acre in the hilly areas, 0.5 acres is dry land, but available for farming. In May 2019, Adaribariki Seethamma started practising pre-monsoon dry sowing. She applied 200 kg of ghanaejevamrutham (compost made from cow dung, cow urine, jaggery, pulse flour, uncontaminated soil, etc.) and ploughed the soil minimally. On the 15th May, she sowed seeds of white rajma, red rajma, maize, tomato, red gram, ragi and other millets, leafy-vegetables and ground nuts. By the 18th May, all the seeds were sown in line after being treated with beejamrutham, a microbial seed-coating – except for groundnut, which was sown separately on the land. Seethamma used dry grass as mulch material and sprinkled soil on top of it to ensure that winds would not sweep it away. In the whole summer, rain only fell on June 6th (3 mm), June 28th (4 mm) and July 18th (7 mm). To cover the water needs of the plants, she started spraying dravajeevamrutham (liquid organic fertiliser) for two weeks, until the completion of the crop cycle.

Farmer Adaribariki Seethamma's motto is not to have her land empty.

Photo: RySS

To protect the crop from mosquitoes and other pest attacks and prevent flowers falling off, Seethamma sprayed Neemastram, a pest-control agent prepared with neem leaves, cow urine, cow dung and water. Tomatoes were the first to get harvested, a few of which she kept for self-consumption, others she sold on the local market and some she distributed in her neighbourhood. Seethamma harvested leafy vegetables almost daily, and there has not been a single day when her income was less than 500 rupees (Rs.). From this income, she is able to purchase groceries and other items for her children and for the house. People are fond of rajma (red kidney bean) seeds, which are grown in the Visakhapatnam tribal area. So, Seethamma started selling rajma on the local market. The gradual increase in the yield from rajma helped to increase her farm income.

She sold groundnuts on the farm itself. People who come to purchase them value them because they are especially sweet. After groundnuts in the Kharif season, she grew ragi, or finger millet. Her motto is not to have her land empty but keep sowing one crop after another. If anyone asks her why she is always doing this, she replies: "If we keep land fallow, weeds will grow, and it will become useless, whereas keeping land covered continuously also provides continuous income." And this has made Seethamma realise that farming can be profitable. She has even started receiving money in advance from others for vegetables.

In 2019, farmer Adaribariki Seethamma earned a total income of Rs. 28,000 from 0.30 acres of land along with food items for consumption, with a bare cost of Rs. 2,300.

has commissioned various studies for the same. These studies are for establishing the science behind natural farming, the socio-economic impact of APCNF, etc. Many more need-based studies are on the anvil. A large number of on-farm experiments are being conducted by young agriculture graduates and champion farmers. These are to help us to improve crop protocols.

Farmers' own experiments are important for the success of the programme. In the first year, they take up only a small portion of land under natural farming, while the rest of the land is under conventional, synthetic chemicals-based agriculture. After seeing the results of the first crop, farmers invariably analyse the differences in the two plots of land in terms of costs, yields, resilience, health impacts, etc. They also discuss aspects with other farmers, and then they take a decision to expand the area. These pioneering farmers are responsible for motivating new farmers to enrol in natural farming, too.

To sum up, the APCNF programme is not only about the natural farming technology, but it is about a proper implementation plan to take the technology to every farmer in the programme villages, and to provide the necessary long-term handholding to the farmers to make the transition. As to date, the programme has a footprint in 25 per cent of the villages of the State, and around 10 per cent of farmers are enrolled in the programme.

The vision of the programme is to take this to all the estimated six million farmers and landless farmworkers in the State, and to bring the entire cultivable area in Andhra Pradesh under natural farming. A very ambitious goal, but given the response of the farmers it is an achievable one.

Vijay Kumar Thallam is Executive Vice Chairman of Rythu Sadhikara Samstha (RySS), a Government Corporation for Farmer's Empowerment, and Ex Officio Spl Chief Secretary to the (Natural Farming) Agriculture and Cooperation Department of the Government of Andra Pradesh.
Swati Renduchintala is a Project Executive with the RySS – APCNF programme.
Contact: swati.r1@gmail.com

Further reading: **www.rural21.com**

Displaced and forgotten

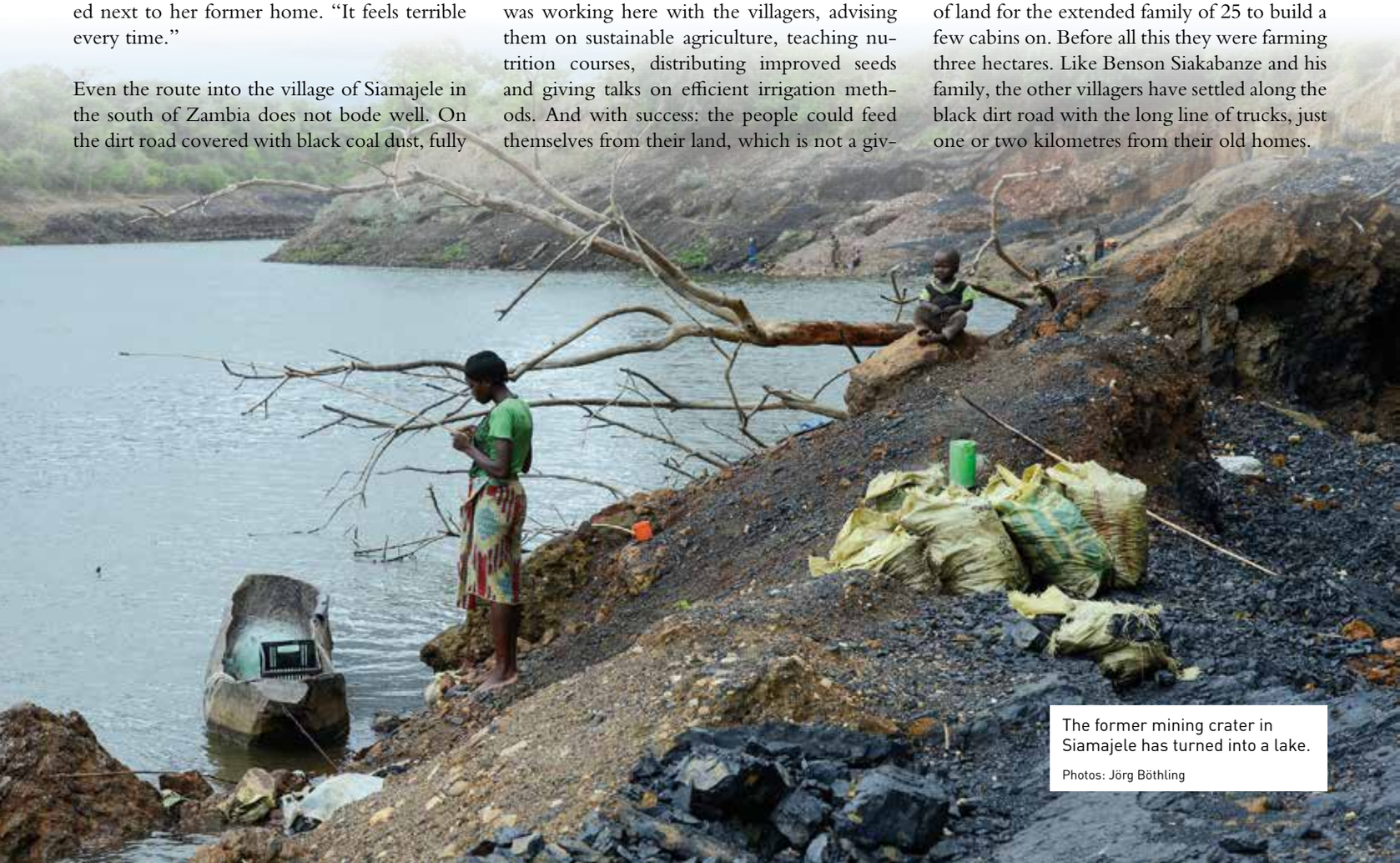
Despite the devastating impacts of climate change on many countries, coal mining continues unabated: some 8.13 million tonnes of the fossil fuel were extracted worldwide in 2019. A visit to the villages surrounding a Chinese coal mine in southern Zambia highlights the consequences for the local population.

By Klaus Sieg

Benson Siakabanze points out a small square, the remnants of walls. "That used to be the house I was born in," he says, and pauses. "And we always sat in the shade under that tree there." Again the 43-year-old falls silent and casts a pensive gaze over piles of stones, overgrown beds and a few abandoned household objects. Along with his neighbour, Rose Chulou, he goes on to show us the fields once farmed by both their families. "Until not long ago, those fields fed our families well." Today the arable land is criss-crossed with dark fissures. Trees are tilted in the ground. A sign prohibits entry. That was put up by Collum Coal Mine, the Chinese company operating the coal mine for which three quarters of the villagers had to make way. Rose Chulou stands at the side of the field, arms folded, ever the farmer. She comes back regularly to pick mangoes from the trees she herself had planted next to her former home. "It feels terrible every time."

Even the route into the village of Siamajele in the south of Zambia does not bode well. On the dirt road covered with black coal dust, fully loaded trucks rumble through deep potholes. Parked at the roadside, long rows of empty vehicles await their loads. The drivers squat alongside them in the shade, some sleeping on mats. "Here there only used to be the village, the fields and the bush," recalls Lillian Hamusiya. She works for the Kaluli Development Foundation (KDF), a partner organisation of the German agency Bread for the World. She greets some women at the roadside who are selling fruit and vegetables to the drivers. It is not the only trade that is booming because of the mine. In dimly lit pubs with names like Bana Bangu Bar, the miners – most of whom are working a long way from home – drink their meagre wages. "Prostitution has also risen a lot, and with it the HIV infection rate."

These women are the first of many people Lillian Hamusiya greets. Until a year ago she was working here with the villagers, advising them on sustainable agriculture, teaching nutrition courses, distributing improved seeds and giving talks on efficient irrigation methods. And with success: the people could feed themselves from their land, which is not a given in this southern Zambian region. All that went down the drain when the ground over the mine workings began to split open about two years ago. "They banned us from working in the fields any more. Many had to leave their homes because of the fissures," recalls Benson Siakabanze. While some residents were given shelter in the church, others had to spend months living in tents, which the authorities took their time to provide after repeated complaints. Only after a television report instigated by Lillian Hamusiya and her organisation did the first residents receive compensation payments. "But at least a quarter of us have still received nothing." Benson Siakabanze's eyes glint with indignation. "These people are still living in the old village and working in their fields." His own family finally received the money last year. But the amount, the equivalent of 250 euros, was only enough for a piece of land for the extended family of 25 to build a few cabins on. Before all this they were farming three hectares. Like Benson Siakabanze and his family, the other villagers have settled along the black dirt road with the long line of trucks, just one or two kilometres from their old homes.



The former mining crater in Siamajele has turned into a lake.

Photos: Jörg Böthling

Benson Siakabanze sitting on the wall remains of his house.

Like the other farmers in her village, Rose Chulou has no enforceable title to her land.

Arnod Maiya and his fellow members of the cooperative cut coal with picks.

Many farmers in the region have to supplement their agricultural earnings by selling charcoal.

Where he now lives, Benson Siakabanze still has a one-hectare plot of land that he had inherited from his father. It goes some way towards feeding the family. Things do not look as good for Rose Chulou and most of the others. With her compensation the widow could only just buy herself a quarter-hectare of arable land. She has to supplement her agricultural earnings by producing charcoal, like many other small farmers in the region. They use machetes to chop down trees and bushes, and carbonise the wood ready for sale at the roadside – with dire consequences for people as well as the environment. "In the constant smoke, it's very exhausting work." Rose Chulou coughs. "And the takings are very low." They are just about sufficient for the three orphans she cares for. So the 49-year-old herself and the other six adults in the household usually have to skip one meal a day.

But even this precarious status is under threat. How long will Rose Chulou be able to use the new farm and her small piece of arable land? The smallholders have no enforceable titles to their land, unlike the Chinese company, which has had a concession from the Zambian government since 2001. And the demand for coal is growing. Mainly from the copper mining area known as the Copper Belt in northern Zambia and the country's numerous cement plants, but also from neighbouring countries like the Democratic Republic of Congo.

Currently the 500 miners are extracting 50,000 tonnes per month from the drifts which are up to 350 metres deep. The safety and environmental standards are catastrophic. Accidents happen regularly and frequently end in fatalities. Added to this, conflicts have erupted time and time again over unpaid wages and tax debts. Violent clashes and even shootings have ensued, claiming the lives of workers and one Chinese manager. The Zambian government subsequently withdrew the concession from Collum Coal Mine. But since 2015 the company has been back in business. It has even been offered an option to extend the mine. The deposit is part of a coal belt that extends all the way to South Africa. Not good news for Rose Chulou, Benson Siakabanze and the other former residents of Siamajele.

Nor for Arnod Maiya, one of Benson Siakabanze's neighbours. The 63-year-old represents a cooperative of people from the region who, besides farming, extract coal themselves in the small open-cast mine behind the former village of Siamajele. Open-cast mining was started by an Italian company at the end of the 1960s. Its heavy machines gouged a deep crater into the land. A sudden ingress of water brought this to an abrupt halt – and turned the crater into a lake. "It happened so fast that they couldn't even salvage the trucks and the heavy milling machines," he recalls. Those are still at the bottom of the lake. Meanwhile on the shore, Arnod Maiya and fellow members of the cooperative cut coal with picks and transport it away in small boats. "Our very survival has depended on it since we stopped being able to work our land."

Arnod Maiya has endured four displacements in his life. When he was a young child, his family farmed fertile land in the Zambezi valley, the river border between Zambia and its southern neighbour Zimbabwe. The first time was to make way for the Kariba Dam, one of the largest on earth. That was in the late 1950s, when the government resettled them here. But not for long. Ten years later, when the Italian company started digging for coal, they had to move again. This time the government gave them land a few kilometres back, in the direction of the Kariba Dam reservoir. "The land was flat and the soils were fertile," he recalls. A major foreign investor thought so too. Yet again, the local population had to make way. In the meantime the Italian open-cast coal mine was under water, and Arnod Maiya's family returned to Siamajele – now beside a lake.

From that time onward, the lake even fed an irrigation system which was built by the residents of Siamajele thanks to the support of a development organisation. "That was a great advance for our agriculture." But then the earth began to split open. "Without our own coal mining we couldn't feed our families," says Arnod Maiya. Yet the Chinese mine operators have been to court once already and tried to put a stop to it. A compromise was found. Since then the cooperative, made up of 200 households, has been allowed to mine 30 tonnes per month. Initially that might sound like a lot. "It's no more than a heap like that." Arnod Maiya points to one of the black heaps where the men of the cooperative have piled up lumps of coal between the shore of the lake and the old village. They are barely any higher than the villagers' modest shacks.

Collum Coal Mine extracts three times as much every single hour. Arnod Maiya shrugs his shoulders and shakes his head. "What will the next thing be?" Then he sets off for home using the black dirt road, past his old village with the derelict houses, skirting the fields no longer tended by Rose Chulou and Benson Siakabanze. It's a far cry from anything resembling a future.

Klaus Sieg writes about agriculture and food, the environment, energy, the economy and social issues. He is based in Hamburg.
Contact: klaus@siegtext.de

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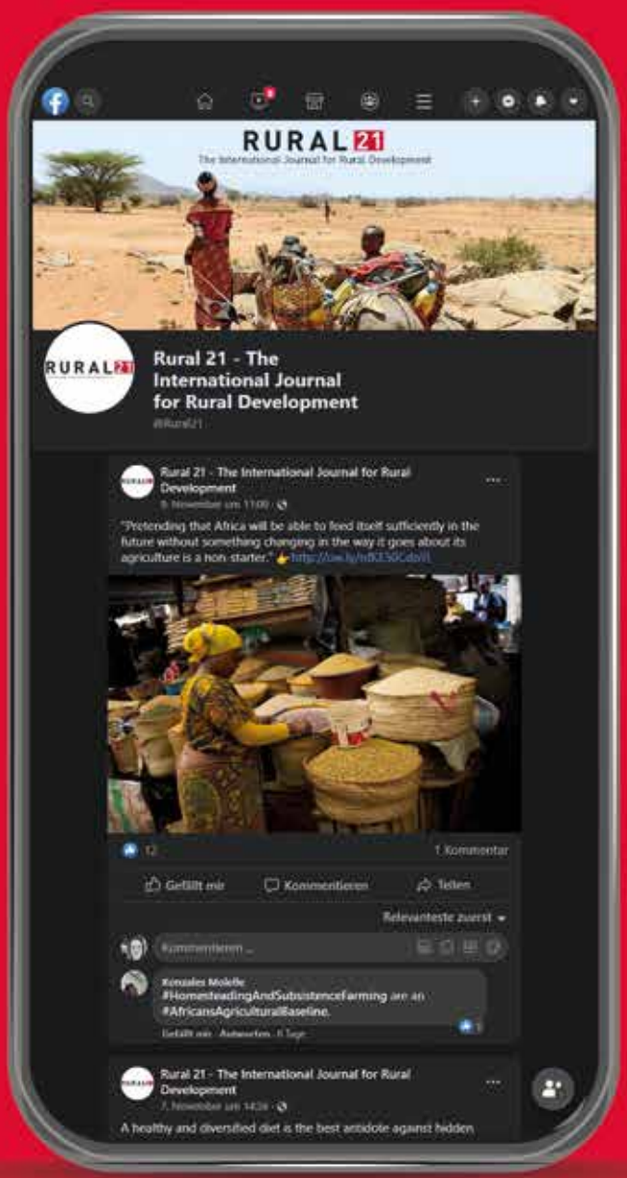

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