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Global Health

A challenge for interdisciplinary research

Human, animal and plant health is a fi eld of work which offers opportunities for inter- and trans-disciplinary research. The whole topic bridges the natural and social sciences. Today, in a world of global environmental change it is widely recognized that human societies and their wellbeing depend on a sustainable equilibrium of ecosystem services and the possibility of cultural adaptation to global environmental change. The need to identify and quantify health risks related to global environmental change is now one of the most important challenges of humankind. Describing spatial (geographic, intra/inter-population) and temporal differences in health risks is an urgent task to understand societies' vulnerabilities and priorities for interventions better. The Göttingen International Health Network (GIHN) is a research and teaching network in relation to this cross-cutting topic. The book provides a collection of articles which contribute to this issue of overriding importance and presents an overview of the GIHN launch event.

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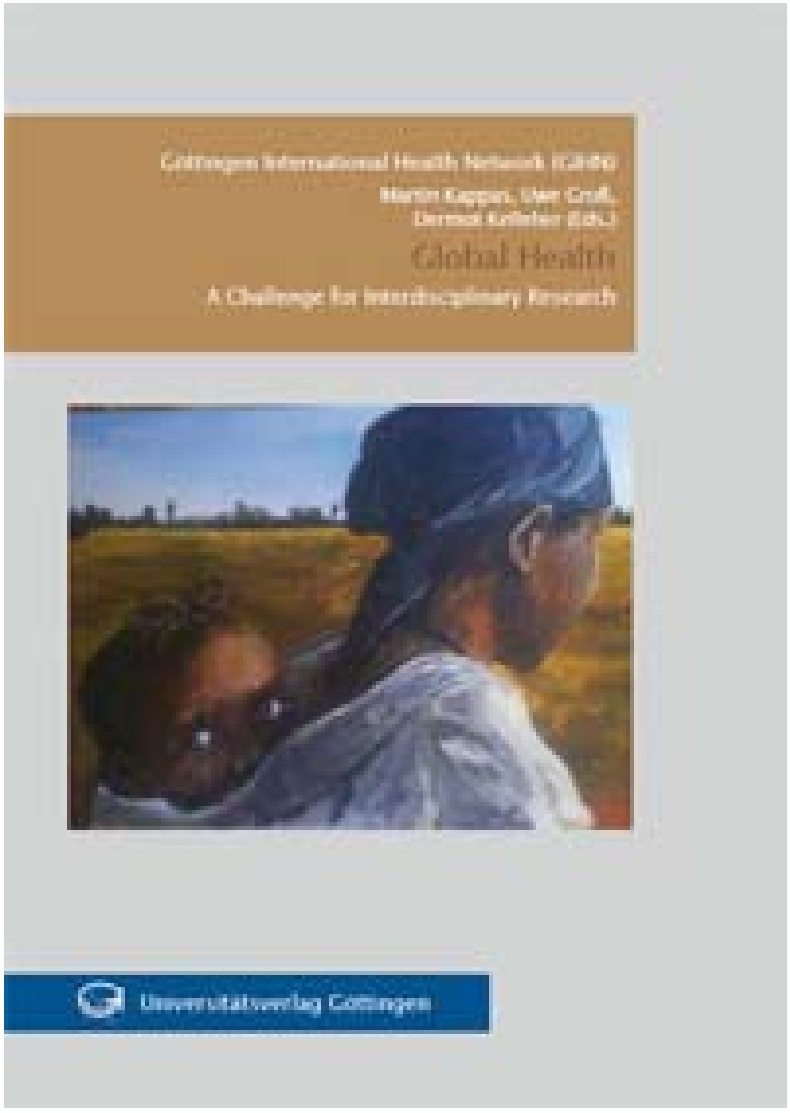

The One Health Concept in a Development Context

Kerstin Wydra

Population increase, climate change, hunger, poverty, inequality …and health

The challenges mankind is facing in the next decades are manifold, encompassing world population growth predicted to reach 9 billion by 2050, climate change with temperature increases and changes in precipitation patterns, and more extreme and unpredictable weather events, which occur with increasingly higher amplitudes and frequencies. Additionally, environmental degradation, in combination with inadequate political frameworks, further contribute to food insecurity, malnutrition, bad health and depletion of natural resources. Among the regions most affected by and most vulnerable to climate change is Sub-Saharan Africa, where variability in onset and extent of rainy seasons, and significant reductions in the length of growing periods forecasted by many of the Global Climate Models as well as steadily increasing desertification and land use and land cover change will have direct impact on agricultural production. Besides the effects of exploitation and further loss of natural resources, the direct drivers of agricultural change, the growing food demand and changes in consumption patterns, are enhanced by factors such as global energy shortage, which further aggravate the situation (IAASTD 2008). As a result, Africa's agriculture, particularly in arid and semi-arid areas, is facing increased abiotic and biotic stress with disease outbreaks and insect epidemics, leading to a decline in crop yields, a decrease in forest and cultivated area shares, and a reduction in ecosystem integrity, associated with a decline in biodiversity. Thus, for large parts of the Sub-Saharan African region, the percentage of "failing seasons" is likely to be in the range of 20-50% by 2050 (Thornton et al. 2006). Existing farm and pastoralist systems and their agricultural practices and pest control measures are not resilient enough to cope with these challenges. In 2010, Sub-Saharan Africa had with 30% the highest percentage of undernourished population comparing continents and an extremely alarming global hunger index in some countries, among them East and Central Africa with 25% to more than 35% of the population being undernourished, respectively (FAO 2010). One of the most evident effects of the climate-related, unforeseen disturbancies are the regional disasters in form of hunger catastrophes.

Additionally to the increasing exposure to environmental stress, small-scale farmers are further challenged by changing socio-economic conditions, which increase risk, as there are population growth, large-scale farming and foreign investment ('land grabbing'). In a vicious circle low agricultural production leads to undernourishment and malnutrition as primary causes of illnesses and death, which further negatively impact food production. In these aspects, the linkages between agriculture and health are obvious.

Associated with hunger is poverty. Sub-Saharan Africa counts for about 75% of the ultrapoor of the world, who live on less than 0.50 US$ per day (Ahmed et al. 2007). In combination with low food production, related low water quality, insufficient sanitation and health facilities and lack of education, specifically of mothers, poverty contributes to a high vulnerability of households and an overall poor livelihood. This interrelatedness of factors governing the living conditions in developing countries demands innovative, integrated and interdisciplinary approaches to reach development goals. One prerequisite to reduce poverty and improve nutrition and health is building on agricultural knowledge and innovation in local and traditional societies (IAASTD 2008).

Climate change and health

Climate change will have impact on the distribution, epidemiology and severity of diseases, and make controlling existing diseases more difficult (Campbell-Lendrum, 2011). The impact of climate change on health will manifest in direct effects, such as outbreaks of diseases among human populations, and indirect influences such as disease calamities of domesticated animals or plants, which endanger food security, economic stability and trade. Disease control under changing conditions in agricultural production has to be adapted, since host resistance and pathogen virulence may change. Further impacts on crop yields and the environment which indirectly affect health are given below.

Millenium Development Goals

As a response to the challenges of global change and population growth, in year 2000 the eight millennium development goals (MDGs) were defined and adopted by 170 heads of state. To achieve the MDGs as prospected for year 2015, the development of an intersectoral framework is needed that facilitates the exploitation of synergies between agriculture and health and supports joint policy formulation (von Braun et al. 2010). Therefore, the one health concept linking the sectors agriculture, environment and health is important for most of the MDGs. As outlined below, the interactions between the different sectors are numerous, and policymakers, scientists and donors need to be convinced of the enormous opportunities for development through synergistic effects by a close collaboration between the various sectors.

The One Health Concept

Existing and emerging challenges and threats encompassing plant, animal and human diseases, water scarcity, chemicals in the environment, loss of biodiversity and land degradation and loss of agricultural land need to be addressed in a one-health approach which also considers measures to mitigate climate change and socio-economic conditions. The one health concept integrates human medicine, veterinary medicine, plant pathology and plant protection and environmental health, encompassing the natural and the human environment, the latter covering the social, political, structural and institutional framework. Not the overlap of disciplines is searched, but one holistic approach entangling the diverse aspects of each discipline.

One Health is the collaborative effort of multiple disciplines-working locally, nationally, and globally – to attain optimal health for people, animals and our environment.

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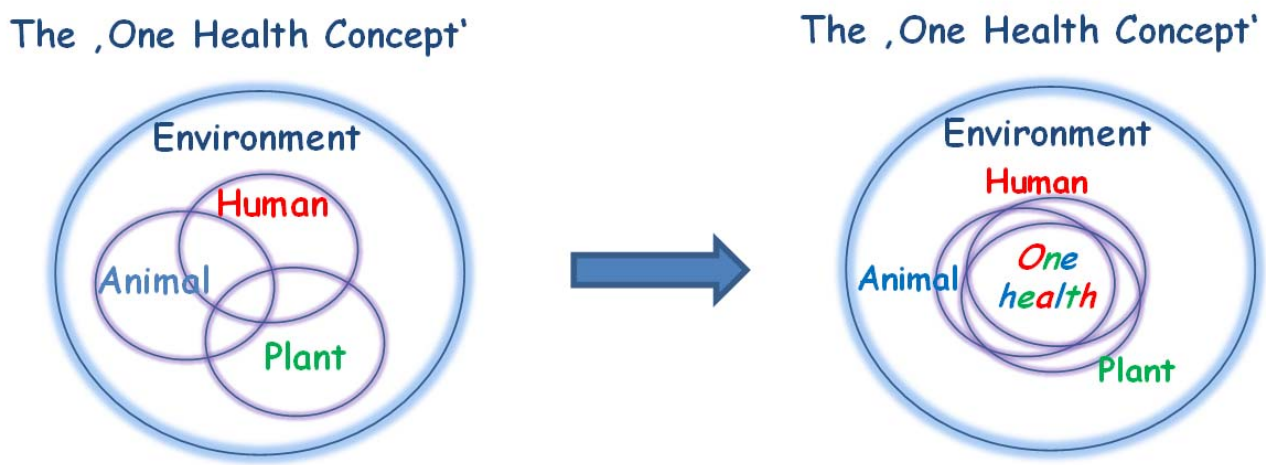

Linkages between agriculture and health

Agriculture is related to many of the world's major health problems, through food production and the environmental impact of agriculture. In the food systems linkages to health occur at all steps along the value chain, from natural resources and inputs to primary production, transport, storage, processing, followed by secondary production, further transport and storage, to consumption (Pinstrup-Anderson 2010). The conceptual framework of linkages between agriculture and health is operating on three levels: across the top level the agricultural supply chain with agricultural producers, agricultural systems and agricultural outputs, which are linked through intermediary processes to the second level – labor processes, access to and impact on natural resources (water, land, biodiversity), income generation and provision of health-related services, and to the bottom level, representing the health problems, undernutrition, water-associated, vector-borne diseases (e.g. in relation to irrigation and land degradation), foodborne diseases and occupational health hazards (Hawkes and Ruel 2006). Through linking the agriculture and food system to health, health becomes a critical driver of agricultural change (Hawkesworth et al. 2010). Health issues linked to agriculture encompass direct effects of low and insufficiently diverse agricultural production such as hunger and malnutrition, and also cover health related indirect consequences of unsustainable production, which can cause foodborne diseases resulting from infections and intoxications, and vector-borne diseases, which are enhanced under specific production systems and occupational health hazards. Nevertheless, agricultural policy to date has been focussing on maximizing production, thereby neglecting environmental health issues as well as biodiversity, which are an important basis for sustainability and sufficient micronutrient supply. The often bidirectional cause-effect relationships between agriculture and health are outlined in detail in the following.

Hunger and malnutrition

Hunger is the most obvious and direct effect of failed agricultural production on human health. Besides hunger the fact of malnutrition as most important cause of diseases and death worldwide is often neglected. About 53% of deaths among children of below five can be attributed to malnutrition (Caulfield et al. 2004). In the recommendation of the Copenhagen

consensus 2008 (http://www.copenhagenconsensus.com), eight world leading economists identified the top ten solutions for the world problems, of which five involve nutrition issues. A balance of nutrients forms the basis of a healthy diet, which should include the four micronutrients zinc, iodine, iron, and vitamin A which are in chronically short supply. This hidden hunger in form of micronutrient deficiencies affects more people – about 2 billion - than the lack of calories which about 800 Mio people in the world suffer from. The promotion of micronutrient-rich food combined with behavioural change is a recommended strategy which has to be followed in an intersectorial approach, between farmers, traders and consumers, and on policy level (Hawkes and Ruel 2006).

Food safety and water safety

Food-borne diseases caused by contaminations through pathogenic micro-organisms and toxic organic and inorganic compounds are among the most important reasons for illnesses in the population of the developing world. Many of these microbiological and chemical hazards originate from agricultural production, such as zoonotic pathogens or toxins, and contaminated water. Specifically aflatoxicoses caused by mycotoxins may be one of the most important and least recognized health problems (Williams et al. 2004). Staple crops such as maize and groundnut can contain highly toxic metabolites from pathogenic and saprophytic fungi, which develop in the field under conditions of drought stress and erratic high rainfall or high moisture, and proliferate under unsuitable storage conditions, favoured by high temperature and humidity (see also below). Generally, contaminations can occur along the whole value chain, from primary production to harvest, storage, processing and transport, and during food preparation.

Water-borne and water-associated, vector-borne diseases are the cause of death for 3.2 million people per year, which to a significant part are due to the impact of agricultural activity (Nugent and Drescher 2006). Irrigation water and stagnant water are related to agricultural practices and provide breeding ground for disease vectors. Further impacts on food safety derive from pesticide residues in intense agricultural production, which endanger humans and the environment. Water-borne diseases including zoonoses as well as contamination of water supplies with chemicals, toxins and by-products of drugs and hormones are typical examples, which demand a solution under the paradigm of an one health approach.

Zoonotic diseases

Zoonotic diseases are the main factor of infectious illnesses in the developing world. They originate with animals and are transmitted directly from animals or through a large number of pathogen-transmitting insect vectors, contaminated water, or bad sanitary conditions with humans and livestock living closely in the same space. Pathogen transmission for livestock-related zoonoses in more densely populated areas with frequent contact between animals and humans will be increasing, the rate of development of pathogens may become enhanced, the geographic range of vectors and their competence may change with variations in weather (temperature, humidity, rainfall, precipitation) and land use, increasing suitable habitats for water-related vectors. Recent emergence of serious zoonotic diseases such as *Salmonella* spp. and *Campylobacter* spp. from poultry, bovine spongiform encephalopathy (BSE), *E. coli* infections, the severe acute respiratory syndrome (SARS) and avian influenza are all related to animal production practices (Todd and Narrot 2006). Transmission can be through vectors, but also through contaminated water, crops, other animals, specifically where animals are kept in dense populations and close to human living grounds. All these hazards related to livestock production are expected to increase in the coming decades due to a rapidly increasing demand for animal products. About 21 billion food animals are being produced with 15 millions of tons of animal and agricultural products being transported worldwide. The future increase in

animal production will occur predominantly in developing countries which have major deficits in monitoring and controlling disease and thus pose a threat to the global food system and human health worldwide.

Crop protection and health

Occupational hazards related to crop protection include health risks from pest control through use of chemical pesticides, with both acute effects and long-term harms to health (Williamson et al. 2008). Besides the exposure of farmers during application, toxic compounds occur as residues in the food supply, in the environment and in the water. A wide array of abiotic and biotic factors such as insects and pathogens causes major yield losses through the impact on quantity and quality of crops, which in turn leads to malnutrition and hunger, thereby closing the vicious cycle of negative health-agriculture feedbacks leading to poverty with subsequent negative impact on agricultural production. Mycotoxins produced by pathogenic and saprophytic fungi such as *Fusarium* spp., and *Aspergillus* and *Penicillium*, respectively, have a direct negative health effect on consumers and can cause liver cancer, stunting, low birth weight and other severe impacts on health. Some measures are available to reduce mycotoxin contamination before harvest and in the storage, as recent development of a biological control through application of atoxigenic strains of *Aspergillus flavus* by the International Institute of Tropical Agriculture (IITA), while awareness among farmers and consumers and suitable monitoring systems are still insufficient or missing.

In reaction to the high pressure from increased populations, climate change and global change, traditional, more resilient production systems are more and more abandoned in favour of high input mostly monocultures based agriculture, which reacts highly sensitive to any stress and to lack of external input, when not available. Only sustainable intensification considering the principles of integrated pest management and biological control, in combination with measures to support soil health and mixed cropping systems, as part of an integrated crop management can contribute to enhanced human, plant and environmental health, and thereby supporting human wellbeing and rural development.

Natural environment and health

Ecosystem degradation

The impact of the environment on health of children < 14 is higher than for the general population. Children are 44% more likely to die as a result of environmental factors. Globally, almost 25% of the diseases are related to environmental factors, with 94% for diarrhoea, 42% for malaria and 41% for lower respiratory infections (Prüss-Üstün and Corvalán 2007). Ecosystem degradation will be enhanced by a predicted 30-85% increase in water withdrawal and a 100 to 1000 fold increased extinction of species for the next 40 years (Millennium Ecosystem Assessment 2005: http://www.millenniumassessment.org/en/index.html). Environmental degradation such as erosion, salinisation, soil nutrient depletion and water contamination and scarcity caused by agricultural practices will contribute to declining agricultural productivity, resulting in malnutrition and illnesses, which again will reduce labour productivity, resulting in unsustainable agricultural production and further negative impact on the environment. The health effects range from undernutrition to increased occurrence of water-borne diseases, altered transmission mechanisms for infectious diseases and intestinal, respiratory and other disorders, leading to decline of farm income with its negative effects on health and health care (Nugent and Drescher 2006).

Agrobiodiversity and health

Agrobiodiversity is a basis for food security and provides famine food in times of hunger as well as micronutrients to alleviate the effects of malnutrition. Inter- and intraspecific biodiversity is a source of genetic resources and the basis for breeding for more resilience to biotic and abiotic stress and to increase the content of miconutrients. Neglected crops, specifically vegetables, contain high levels of carotinoids such as lycopene and lutein, and beneficial compounds with functional properties, such as flavonoids and phenolics which act as antioxidants and contribute to reducing the risk of chronic diseases and cancer. Successful examples of increased content of micronutrients through introduction of genes from neglected species through classical breeding are available and already propagated in various African countries, such as the Vitamin A rich sweet potato. When plant produce enters the market chain agrobiodiversity can directly contribute to income generation. Moreover, biodiverse systems improve environmental quality and ecosystem services for agriculture, such as nutrient cycling, soil fertility, provisioning services supplying food, water, wood and fiber, regulating services such as climate regulation, disease regulation, water purification and cultural services, which all directly or indirectly impact human health. Thus, agrobiodiversity combined with indigenous knowledge as part of locally available resources has the potential to positively influence the entire agriculture-food-nutrition-health structure (Gari and Villarreal 2002).

Environmental pollution

Hazards to the environment and thereby to human health can originate from intense agricultural production, such as contamination of water with fertilizers (nitrates and others), pesticide residues and pollution of water and air through intense livestock production systems with huge amounts of livestock-derived waste (Catelo 2006). Agricultural chemicals accumulate in environmental sinks such as soil, air, water and plants, to which humans are exposed.

Agroforestry, nutrition and health

Agroforestry systems represent through integration of crop and tree diversity in a production system a sustainable basis for environmentally sound agricultural activity and increase the flexibility and adaptability of the system. They are a source of medicinal products from trees, shrubs and herbs used in traditional medicine across much of Asia, Latin America and Africa. Moreover, agroforestry systems provide fruits, leaves and other products of high nutritious value which increase the dietary diversity for the rural and, if marketed, also the urban population, and which serve as animal feed. Fruits and berries are preferably consumed by children as a study in Zimbabwe showed (cited in Swallow and Ochola 2006) and also contribute to household income when entering the market chain. In terms of environmental impacts, agroforestry systems are the basis for a sustainable crop production by providing niches for beneficial insects such as bees or parasitoids and predators, which have the potential to balance the outbreaks of pests, and by a sustainable nutrient cycling process with positive effects on soil fertility.

Human environment: Socio-economic and structural factors influencing health

Demographic factors and conflicts surely play major roles in human welfare in developing countries. Though not neglecting these circumstances, long term changes need sustainable solutions based on well functioning structures. Obstacles for improved strategies in developing countries are besides a lack of coordination and a poor infrastructure the knowledge gaps on the ways of contamination of food, on epidemiological cycles of zoonotic diseases, and thus of adequate management strategies. Successful strategies developed

elsewhere, such as agricultural interventions to control the spread of water-associated diseases, are available and can be transferred and adapted to local conditions (Mutero et al. 2006). This implies that a major effort is needed on all levels, from research to implementation, from community to policy level, including organizational and infrastructure development. To develop efficient intervention strategies to improve food security and food safety in relation to health, risk analyses are one tool to choose among various management options to reduce foodborne diseases and other hazards related to agriculture, which affect human health.

Opportunities linking agriculture, environment, food security and health

Linking the agricultural and the health sector provide unique opportunities to improve health and human welfare in the poor countries. Thereby, promotion of agriculture considering health aspects and, in a two-ways approach, improving health-related problems considering their impact on agricultural production and the environment has the potential to significantly and sustainably enhance the nutrition and health status of the poor population. As stated by the IAASTD (2008), a report accomplished by several hundred scientists, signed by 58 countries, agricultural growth of small-scale farms is the best way to generate income and reduce global poverty. Considering environmental factors, as outlined above, the vulnerability of the ecosystem to climate change and changes in land use patterns will clearly influence agricultural production and biodiversity, and thus improvements on one side will positively affect the entangled sectors.

To achieve considerable impact, linked agri-food and health governance structures have to be established, which reduce institutional barriers and are the basis for intersectoral research and policymaking. Encouraging intersectoral initiatives are being developed in the recent years by the World Health Organization (WHO), the Consultative Group on International Agricultural Research (CGIAR) with a platform on ‘Agriculture and Health’, and by the International Food Policy Research Institute (IFRPI) which organized international conferences on the subject, to name only few.

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