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Bioeconomy – a future for farmers in the South?

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Editorial

Dear Reader,

Bicycle frames made of bamboo, kerosene made from algae, trainer soles out of rice husks – there seem to be an infinite number of ideas when it comes to replacing fossil, finite raw materials with renewable, seemingly infinite resources. The proponents of the economic approach summarised as the bioeconomy are not only focusing on using renewable raw materials. Rather, they regard their concept of "biologising the economy" as an opportunity to redesign the global system of production and consumption in a manner guaranteeing a secure sustainable base in every respect. This would be a gain for all – human beings and the environment, business and consumers, North and South. It indeed seems an ambitious project. This edition takes a look at whether the promises made in the context of the bioeconomy really can be kept and, above all, what conditions then have to be fulfilled.

In his introductory article (p. 6), Joachim von Braun, Chairman of the German government's Bioeconomy Council, introduces the bioeconomy concept. In what context has it developed, who are the drivers, where are the potentials, and what dangers exist? Which branches are going to benefit most from the planned reshaping of the global economic system, and who will be the possible losers? We will deal with the individual aspects in the following articles – always with a view to the issue of how the concept may impact on the livelihoods of people in the South and whether income opportunities will arise for the rural regions. Here, the chief question is always how adopting a bio-based economy can affect global food security. Is this issue at all addressed in the national bioeconomy strategies, and if so, what status does it have? (p. 10) How can the eviction of people from their land, the neglect of food production and violations of the right to food caused by the rising demand for biomass be prevented? (p. 19). Which approaches are there in politics, science and civil society ensuring that the research results and innovations crucial to the bioeconomy can also find their way into the rural areas of the South? And that the contents do not bypass people's needs at local level? (pages 14–18 and 27)

Alongside technological innovations, the core of the bioeconomy is an optimally efficient and sustainable use of existing natural resources – this means e.g. using, wherever possible, all parts of a plant for as many types of use as possible, so that the product life-cycle is optimised. You can find examples of this in our Scientific World section (pages 28–31).

Political strategies and exploring potentials are one side of the coin, while practice is the other. We wanted to find out how enterprises for which the bioeconomy already constitutes an important pillar of their activities assess the potential. We asked two entirely different representatives about this: Marcel Wubbolts of the Dutch-based multinational company Royal DSM, which specialises in the production of a wide range of bio-based chemicals and materials (p. 22) and Germany's C.S.P. GmbH, which has set itself the task of bringing the supply and the demand sides together in the field of bio-based raw materials (p. 24)

Finally, we wanted to know whether the authors of our Opinion section generally regard the bioeconomy as a suitable option to solve the urgent problems humanity is facing today. No, says Barbara Unmüßig of the Heinrich Böll Foundation, for just like the green economy, as part of which it sees itself, it has subscribed to the maxim of growth (p. 34). Possibly, but not in the given framework conditions, maintains Adebayo Abass of the International Institute of Tropical Agriculture with a view to Africa (p. 32). Björn Schildberg of Germany's Ministry for Economic Cooperation and Development (BMZ) and Marita Wiggerthale of the non-governmental organisation Oxfam discuss a topic that is just as controversial: whether government development co-operation should join forces with private industry in its projects (pages 36–37).

The Republic of Niger ranks last on the Human Development Index of the United Nations. State President Issoufou Mahamadou has set himself the task of reforming agriculture and stock farming on a grand scale within the next five years. But without the work of the Catholic Church and the support of the World Food Programme, it would hardly be possible to combat hunger (p. 38).

As like in many other countries, it is above all women and children in the remote rural regions of India who suffer from poor health services. They are supported by rural health workers, whose activities are however complicated by a wide range of restrictions. A new ICT tool has proved to be a promising aid (p. 41).

We wish you inspiring reading!

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Photo: C. Kovermann/terre des hommes

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Photo: A. Abass

Photo: A. Mathur

Where are we with the MDGs?

One year before the Millennium Development Goals (MDGs) expire, progress remains mixed. In terms of positive results, some of the MDG targets have already been met – the ones on poverty reduction, access to improved drinking water, life improvement for slum dwellers and gender parity in primary schooling; and several more are within reach by the 2015 target date: If current trends continue, the world will surpass MDG targets on malaria, tuberculosis and access to HIV treatment. This is stated in the Millennium Development Goals Report 2014, launched by UN Secretary-General Ban Ki-moon in New York, USA, in the beginning of July. According to the report, over the past 20 years, the likelihood of a child dying before the age of five has been nearly halved, which means that some 17,000 children are saved every day. Globally, the maternal mortality ratio dropped by 45 per cent between 1990 and 2013. Antiretroviral therapy for HIV-infected people has saved 6.6 million lives since 1995, and many more could be saved by expanding these programmes. Between 2000 and 2012, an estimated 3.3 million deaths from malaria were averted due to a substantial expansion in malaria interventions, while efforts to fight tuberculosis have saved an estimated 22 million lives since 1995. However, the report also warns that, despite major progress, some MDG targets are slipping away from achievement by 2015 even though they relate to largely preventable problems with available solutions, such as reducing child and maternal mortality and increasing access to sanitation. Almost 300,000 women died in 2013 from complications related to pregnancy and childbirth. Preventable conditions such as diarrhoea and pneumonia are the main killers for children under the age of five, the report warns. It also points to continuing nutritional failings: in 2012, an estimated 25 per cent of children younger than five were stunted, in the sense of having inadequate height for their age. While this represents a significant decline from 40 per cent in 1990, 162 million young children still suffer from preventable chronic undernutrition.

Education and employment giving cause for concern

The umbrella organisation of the non-governmental development organisations in Germany, VENRO, points to a further MDG goal that has not been given too much public attention: productive employment and decent work for all. Fifty-six per cent of all employment relationships in developing regions continue to be classified as insecure, whereas the rate for developed regions is ten per cent. A disproportionately large share of people working in such conditions are female, usually enjoy no adequate social security, and suffer from too low an income and harsh working conditions that may even violate their basic rights.

The balance is also negative in the education sector. "There is no chance whatsoever that countries will reach the goal of universal primary education by 2015," Director-General Irina Bokova of the United Nations Educational, Scientific and Cultural Organization (UNESCO) commented when presenting a policy paper in late June. Global progress towards universal primary education has halted. One reason for this is a decline in funding. According to the policy paper, international development aid for education has dropped by ten per cent since 2010, once again reaching its 2008 level. In sub-Saharan Africa, where half of all out-of-school children live, twelve countries were affected by cuts in international support for primary education amounting to ten million US dollars (USD) or more. India and Pakistan, two of the five countries with the largest numbers of out-of-school children, saw the biggest cuts in aid between 2010 and 2012, totalling 278 and 60 million USD respectively. According to the Education for All Initiative, the OECD is reckoning with contributions stagnating from 2014, and for the poorest countries, above all in sub-Saharan Africa, a decline by 500 million USD.

Combating hunger must not be neglected

The German NGO Welthungerhilfe above all stressed that the key objective of halving the proportion of undernourished and hungry people worldwide had not been achieved. The organisation warns that at 842 million, the absolute figure for people without enough to eat remains frighteningly high. Progress in eradicating hunger has slowed. It is very unlikely that the target of halving the prevalence of hunger by 2015 will be met. In particular, regions such as sub-Saharan Africa and Southeast Asia are still far from meeting this goal. "The human right to food must again be given priority in the next phase," argues Wolfgang Jamann, Secretary General of Welthungerhilfe with a view to the Post-2015 Agenda, which is to replace the MDGs. *(sri/wi)*

Global progress towards universal primary education has halted. Half of all out-of-school children live in sub-Saharan Africa.

Photo: U. Tietze / terre des hommes

In brief

"Global leverage points" for sustainable food security

According to an international research team made up of experts coming from the universities of Minnesota and Harvard in the USA and Bonn, Germany, it is clearly possible to provide much more food on a sustainable basis. In their study, published in June 2014 in the international magazine *Science*, the scientists present important "leverage points" in the global food system that offer the best opportunities to improve both global food security and environmental sustainability. To this end, the scientists have examined the difference between potential and actual crop yield. In certain regions, farmers could harvest up to ten times as much by adopting improved cultivation methods. In other words, these places have a huge "yield gap" of 90 per cent. "If we closed just 50 per cent of the gap, we could feed around 850 million more people," one of the authors, Stefan Siebert from the University of Bonn, believes. Efforts to achieve this should concentrate on Africa, Asia and Eastern Europe, since these regions have the potential to produce food for an additional 780 million people. The researchers also call for a halt to rainforest conversion into arable and pasture land. The trend towards rainforest destruction is headed by Brazil, a country that accounted for a third of global depletion between 2000 and 2012. Indonesia takes second place with 17 per cent. The consequences include dwindling biodiversity, accelerating climate change and widespread desertification – impacts that, as the research team warns, may push even more people into chronic hunger. The study also shows where the strategic use of water and fertiliser will make most sense. Moreover, the experts have identified the regions in which food is being used particularly inefficiently post-harvest. An important criticism raised in the study is that, on a global scale, vegetable foodstuffs are used less and less for human consumption. "We grow maize or soya to be fed to our livestock, but we could be eating this produce ourselves," notes Siebert. The problem here is that no animal converts all the food it eats into meat, milk or eggs. In this respect, livestock is never efficient. The production of one animal calorie currently costs more than three plant calories – a loss of 70 per cent. As for using arable land to grow energy crops, this switch is entirely at the expense of human nutrition.

(wi/Science/University of Bonn)

New online food security information service

The Thomson Reuters Foundation and the UN Food and Agriculture Organization (FAO) are planning a joint online food security information service. The Thomson Reuters Foundation is the corporate charity of Thomson Reuters, the global news and information provider, and is headquartered in London, United Kingdom. The agreement signed by the Foundation and the FAO foresees the creation, as of next autumn, of a new section on www.trust.org, the Thomson Reuters Foundation portal, dedicated entirely to delivering news content on hunger and food issues. Stories will be produced and sourced by the Foundation and made available for free usage worldwide in order to spread information on food security as widely as possible. Topics to be covered will include food production, food security and safety, food waste, agriculture and land use, undernutrition and malnutrition, and food affordability among others.

(FAO/ile)

World Bank study: Climate change is accelerating urbanisation

A recently published World Bank study suggests that climate variation has a significant impact on urbanisation in sub-Saharan Africa, primarily in more arid countries. By lowering farm incomes, reduced moisture availability encourages migration to nearby cities, while wetter conditions slow migration. The evidence for rural-urban income links shows that in countries with a larger industrial base, reduced moisture shrinks the agricultural sector and raises total incomes in nearby cities. However, if local cities are entirely dependent on servicing agriculture, their fortunes move with those in the rural sector – reduced moisture tends to reduce local urban incomes. Finally, climate change is likely to result in employment changes within the rural sector itself. Drier conditions induce a shift out of farm activities. Rural females are more likely to report not working, and rural males will tend to move from farm to non-farm work. The study concludes that more severe and persistent climate changes, which will likely increase the challenges faced by Africa's farmers, could further accelerate migration to cities. With global climate change, support for agricultural adaptation and for more effective urban management is therefore an even more urgent priority. *(World Bank/sri)*

"One Agriculture – One Science"

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and universities from India, Africa and USA have launched the initiative "One Agriculture – One Science". The initiative aims at revitalising global agricultural education, capacity building and technology transfer. It is a consortium of agricultural education institutes, research organisations and other related agencies. It is to bring under one roof various disciplines in agricultural education such as crop, livestock, fisheries and natural resource management by providing a common platform to address pressing global agricultural and food security challenges. Through partnerships and knowledge networks, participating institutions shall offer short courses, student scholarship programmes and collaborative research opportunities addressing these challenges. The launch was attended by representatives from universities in the USA, the Indian Council of Agricultural Research (ICAR), the African Green Revolution Alliance (AGRA), the Regional University Forum for Capacity Building in Agriculture (RUFORUM, a consortium of 42 universities in 19 countries in Africa), and centres of the Consultative Group on International Agricultural Research (CGIAR).

(ICRISAT/wi)


Photo: Bilderbox.com


Photo: J. Boething

Bioeconomy and sustainable development – dimensions

Economic growth coupled with environmental sustainability – that is the promise of the bio-based economy. This article outlines the potential of this approach, the possible risks and the steps that must be taken if this potential is to be realised in developing countries as well.

The German government's Bioeconomy Council defines the bioeconomy as "the knowledge-based production and use of biological resources to provide products, processes and services in all economic sectors within the frame of a sustainable economic system." The vision of a sustainable bioeconomy is the comprehensive "biologisation" of the economy, with new bio-based industrial processes and products (e.g. bio-based plastics, building materials, etc.) and changes in consumers' behaviour. Ultimately it is about a sustainable growth strategy that creates ecological and economic harmony. Biomass is an important resource for this: it will need to be produced in larger quantities and processed more efficiently. This provides employment and value-creation opportunities for developing countries. A bioeconomy strategy will require broad-based technological and institutional innovation. Although this will need to take very different forms in industrialised and developing countries, global learning and exchange of bioeconomic innovations will become an increasingly important aspect of it, in particular in order to avoid adverse effects for food security.

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What are the challenges that we face?

World population growth, climate change and the need to protect the natural environment pose major challenges. The future of humankind depends to a large extent on reliable and secure access to food, energy, water and raw materials. To safeguard access to these resources for future generations, production and consumption must be modified so that it is ecologically and socially sustainable – which it cannot be unless it is fed from renewable sources. This is where the bioeconomy comes in. If the bioeconomy is to be realised, a nationally and internationally appropriate enabling environment must be created. In particular, the enabling environment must cover the production, use and trading of biomass, ensuring that the relevant processes are sustainable and fair. In the face of rising demand, conflicts of objectives are bound to arise. However, the appeal of the concept of the bioeconomy is that ecologically sustainable production and consumption is rewarded with technological and economic opportunities. New complementarities emerge, but also competitions. For example, in an inappropriately designed bioeconomy food security may be adversely affected, while economic efficiency and sustainability may be increased. What is needed is therefore holistic consideration of synergies between biomass production, new technologies for processing biomass, and new links within and between value chains, in particular in connection with the manufacture of biofuels and bio-based chemicals and the use of the residues of bio-based


Photo: C.S.P. GmbH


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products in the chemical and construction materials industries. The risks of the bioeconomy must be countered with increased investment in research and technology and the development of markets.

The drivers

Fossil fuels formed the foundation of economic growth and have underpinned development since the industrial revolution. Today, the bioeconomy is about significantly more than the substitution of energy resources. Its opportunities lie in the refining of products, giving rise to completely new product lines for the end consumer, and in new, efficient processes.

The vision behind the bioeconomy is therefore that of an efficient use of bio-based resources, new technological opportunities and altered patterns of consumption, especially in the wealthy countries. A coordinated and long-term bioeconomy policy that considers emerging changes of prices, fosters technological innovation and develops demand is a key driver of the bioeconomy. New products come with the promise of being more natural, healthier and more sustainable. They are being advanced by numerous manufacturers of consumer goods who promote appropriate products and bio-based processes and packaging. In addition, climate change makes investment in the bioeconomy attractive: firstly, because it is necessary to put the energy supply on a new footing that can include biomass to some extend; secondly, because of the need to counter the impending risk of falling crop harvests; and thirdly because markets for greenhouse gas emission rights could in future increase the incentive for biomass stocks for carbon capture to de-carbonise the atmosphere.

International trends

The bioeconomy is not an example of sudden hype but has developed gradually. The concept was first defined in 1997 by Juan Enríquez-Cabot and Rodrigo Martínez. As leading international organisations, the OECD and the EU were quick to recognise the potential of the bioeconomy. In Europe the idea of a bio-based economy has been debated since the late 1990s. The concept of a knowledge-based bioeconomy was first officially introduced in 2005 by Janez Potočnik, then the European Commissioner for the Environment. Under Germany's presidency of the EU Council it was taken further with the Cologne Declaration. Under the title "En route to the bio-based economy" the focus shifted to food, biomaterials, bioprocesses, bioenergy and biomedicine. The EU and Germany – as a pioneer at national level – adopted clear strategies to promote the bioeconomy (see also the articles on pages 10–15). In 2009 the German government convened a council of political and scientific experts, the Bioeconomy Council, which advises policy-makers on issues relating to the bioeconomy. In the last five years a large number of countries – most of them industrialised nations but including some newly industrialising ones – have drawn up bioeconomy strategies and incorporated them into their scientific and economic policy at national level (see pages 10–13). All the G7 and many of the G20 states are now including the bioeconomy in their economic strategies. The key arguments in this debate are as follows:

- The bioeconomy is driven by shifts in the prices of resources and the factors of production (land and labour; energy) and by associated price structures, as well as by technological opportunities and altered consumer preferences.
- The bioeconomy provides opportunities for employment, income generation and investment in agriculture worldwide. At the same time, though, there is a risk of exacerbating the scarcity of biomass. Biomass-based products compete with the supply of food. This could have particularly adverse effects on the poor unless new technologies ensure that possible scarcities are compensated or, if possible, overcompensated for, or unless social protection mechanisms are expanded.

Potentials

The bioeconomy enables economic growth to be combined with ecological sustainability. It is therefore a core element of sustainability concepts such as the "green economy".

It is estimated that a systematic shift to cultivated biomass and biological production processes could cut CO_2 emissions in Europe by up to 2.5 billion tonnes per year. Some 13 billion tonnes of biomass are available globally. Around 60 per cent of this is used for animal feed, 15 per cent for food and 25 per cent for energy or as an industrial feedstock. The most important bio-based industrial products are (currently) specialty chemicals, plastics and composites, surfactants, lacquers and paints, lubricants, paper and cellulose, building materials, furniture and pharmaceuticals. The most important energy products are biogas and biofuels. Technological progress, especially in the life sciences, is expected to lead to the development of new products that combine sustainability with increased consumer utility. Important companies in the bioeconomy are Novozymes (biotechnology, Denmark), DSM (chemicals, Netherlands), Cargill and DuPont (chemicals, USA), and also large food companies (Nestlé, Switzerland). In Germany chemical companies such as BASF, Süd-Chemie, Evonik and Symrise (flavourings) and Continental (automotive parts) are prominent in the field.

Innovation is often driven by research-oriented small and medium-sized biotechnology companies. In Germany about 12.5 per cent of the workforce depends on businesses that can be classed as part of the bioeconomy. They generate around 7.6 per cent of gross value added in Germany. Twelve per cent of value creation in the bioeconomy takes place in the primary sector (agriculture and forestry), 52 per cent in the secondary sector (processing) and 36 per cent in the tertiary sector (trade and services). Key areas include the energy industry – 7.6 per cent of energy consumption is met from cultivated biomass – and the chemical industry: 13 per cent of the resources processed in this sector are bio-based. Many bio-based products are already on the market or in preparation. The bioeconomy embraces all sectors, penetrating the entire economy: in this respect it is comparable to information and communication technology. This means that there are a vast number of interwoven value chains with biomass as their starting point; the task is to optimise this value creation network.

Food security policy in the context of the bioeconomy

Uncertainties in the food and nutritional situation imperil the prospects of the poor, especially in low-income countries. The bioeconomy must above all promote food security. The advantages and disadvantages of the bioeconomy in relation to food security must be considered from at least two angles – firstly, competition in related markets and the resulting impact on prices, and secondly the synergies that arise from the use of technology related to the bioeconomy and food security and that affect the income situation of the poor.

It is likely that the demand for biomass will rise not only as a result of world population growth but also because of the rising demand for biomass for industrial and material uses. The bioeconomy alters the balance of the global food situation: it does this on both the supply and the demand side and so may affect food security. On account of this there has been much debate about solutions to the "food/fuel/feed" competition problem. The following usage priorities, the "5F", are now generally accepted: food, feed, fibre, fuel, forests. In other words, biomass should first be used to feed people before it is used as animal feed, as a raw material for industry or for energy in the form of fuel. Where possible, use should be cascaded, following the 5F sequence of priorities (see article on pages 28–29). New scientific concepts are needed to enable conflicts of objectives that arise to be resolved with the help of technology, organisational innovation and trade.

The linkages between biofuels and food security are evidenced not only in commodity market trends, with rising prices for agricultural products such as cereals, but also in the markets for land and water. The sharp increase in land acquisitions, in part for the purpose of growing biofuels, demonstrates that the strong demand for biomass has become an international issue. In the often non-transparent markets for land ownership, in which power is usually more important than efficiency, more must be done to protect the rights of poor landowners in dealings with investors, especially in the case of small farmers and nomadic pastoralists.

The link with food security shows that new key areas of the bioeconomy are emerging in terms of influencing market development and technologi-

In the often non-transparent market for land ownership, more must be done to protect the rights of poor landowners in dealing with investors.

Photo: J. Boethling

cal progress. For example, sugar and maize crops will not enable sufficient bioethanol to be produced to meet climate and energy targets. Hopes are being pinned on the use of lignocellulosic biomass that is not suitable for human or animal consumption from sites that cannot be used for food production. However, developing efficient extraction processes for lignocellulose will take some time.

Cotton is currently the most commonly used fibre. However, growing cotton requires large quantities of water and fertiliser. In many places, flax and hemp fibres could be produced more efficiently. Plant breeding plays a key part in the development of a sustainable bioeconomy. It can, for example, increase the efficiency of agricultural production and extend the natural range of resources – as in the case of new plant oils containing different fatty acid profiles, which can simplify the refining and chemical modification of the oil in industry. In such contexts biotechnology is a key method for achieving targets such as product quality, increased yield, greater resistance to disease or wider usefulness of by-products.

Viewed as a whole, the bioeconomy changes the competitive situation in relation to food, land and water. Bioeconomy systems that do not put pressure on food security require new types of biomass, multi-tier recovery systems and innovation throughout the value chain. The growing market for biomass and its agricultural basis require a reliable setting for sustainable production and processing.

Enabling the developing world to benefit too: shaping the bioeconomy

The less-developed states have in the past played little part in global value creation. Because they are relatively rich in biomass potential, the bioeconomy could change this. For the future, solutions will therefore be needed that combine economic growth with global responsibility for worldwide nutrition, protection of the environment and climate change mitigation. Unlike oil, gas or coal, biomass is distributed widely across the planet. Developing countries, in particular, have large quantities of renewable biological resources. Provided that cultivation and processing are carried out responsibly, fairly and in accordance with internationally defined social and sustainability standards, these natural resources can be tapped. When correctly organised, a bio-based economic system is therefore able to strengthen the economy of developing countries, create jobs and feed a growing world population. Through its knowledge-based approach the bioeconomy can create the basis for new, fair business partnerships between industrialised and developing countries and remove past conflicts of interest. Industrialised countries want access to biomass resources. Wherever possible, these resources should be processed in developing countries in order to increase value creation there.

In an implicit process of exchange, developing countries should gain greater access to new bioeconomy technologies and related science from industrialised countries. This requires increased co-operation in research partnerships in the public and private sectors. This would give developing countries the opportunity to play an increasingly large part in value creation. In the context of a sustainable economic policy the bioeconomy can thus become a driver of progress and social change – cutting across the present-day rich/poor divide.

As part of far-reaching changes, the bioeconomy should be viewed as social, technological and economic transformation – that is, sustainable transformation – of the economic system. The core of these transformation strategies is not confined to the dimension of technology (novel science) but includes behaviour change (modified consumption) and institutional innovations for enabling settings and long-term incentives, at the level both of companies and of international policy. Internationally harmonised settings enable the potential of the bioeconomy for industrialised, emerging and developing countries to be realised; in other words, they enable the production and use of and open trade in biomass to be regulated fairly. Smart bioeconomy is at the heart of sustainable economic development. For the next generation of scientists, inventors, small and medium-sized enterprises, farmers, and eco and social entrepreneurs it is both a challenge and an opportunity.

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

More co-operation in research partnerships is needed so that developing countries can also gain greater access to new bioeconomy technologies from industrialised countries.

Photo: J. Boethling

Bioeconomy strategies across the globe

Over the last two years, numerous countries have begun to develop more or less comprehensive bioeconomy strategies. The following article looks at the differences between the various concepts and, in particular, the role that they assign to food security.

Published in 2009, the OECD strategy "The Bioeconomy to 2030: Designing a Policy Agenda" gave an important stimulus to the development of national and regional bioeconomy strategies. In 2010, Germany's Ministry of Education and Research published "The National Research Strategy BioEconomy: Our Route Towards a Bio-based Economy", which was then complemented in 2013 by Germany's "National Policy Strategy on Bioeconomy". In 2012, the European Commission issued its Communication on "Innovating for Sustainable Growth: A Bioeconomy for Europe", while the USA published its National Bioeconomy Blueprint in the same year. There are many more countries that have since then come up with bioeconomy strategies (see page 13).

Chief characteristics of bioeconomy strategies

A number of countries are promoting individual biotechnology sectors but have not yet developed a comprehensive bioeconomy strategy. These include the red biotechnology sector (pharmaceuticals and personalised medicine), the green biotechnology sector (transgenic plants and cloned animals) and the white or industrial biotechnology sector, which makes use of renewable primary materials to make bioplastics and biofuels, among other products.

For most countries, the development of the bioeconomy or of specific biotechnology sectors promises innovation, economic growth and job creation. In some cases, the aim is to bring benefits to rural areas by enabling them to supply and process renewable raw materials. A number of countries also justify the development of the bioeconomy with the need to reduce their dependency on oil as well as with their willingness to combat climate change. Through more efficient production processes and the sequestration of carbon in bio-based products, the bioeconomy is said to lead to a reduction in the negative impacts the economy has on the environment. The development of food biotechnology or innovation in the medical sector is regarded as a positive contribution to improving the health of citizens. In addition, the issue of food security is addressed in a number of strategies. To achieve food security for its citizens, a country needs to make sure that sufficient food of adequate quality and diversity is available and accessible to all the people at all times, even in times of crisis. As the bioeconomy creates additional demand for renewable raw materials, hence using agricultural land and other inputs, there may be multiple impacts on food security.

The instruments used to promote the bioeconomy are similar in many strategies. Most countries concentrate on investment in research and development, in the field of life sciences. Moreover, they aim to help the transfer of innovation from the laboratory to the market, often by setting up clusters between academia and business, with the companies involved being supported by tax relief or risk financing, and by forming public-private partnerships. Of equal importance in these strategies is specialist training by offering curricula established in co-operation with companies. Some strategies also anticipate legal and regulato-

The „red" biotechnology sector focuses on developing pharmaceuticals and personalised medicine and plays a key role in many national bioeconomy-related strategies.

Photo: Bilderbox.com

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ry reforms to support the bioeconomy. The European Union and the German strategies stress the need for stronger stakeholder engagement and the exchange of information with citizens.

Individual strategies in more detail

The European Commission

The European Commission's Communication on "Innovating for Sustainable Growth: A Bioeconomy for Europe" can be regarded as quite a broad strategy. It includes the sectors of primary production, traditional wood processing sectors as well as the chemical and bioenergy sectors, making use of biotechnology. The new technologies emphasised in the Communication are biotechnology, nanotechnology and information and communication technologies (ICT).

The European strategy makes several references to the challenge to ensure global food security. It acknowledges that an increasing demand for biomass and competing uses for biomass may be problematic for food security. The need to feed a growing population and the need to sustainably manage natural resources and mitigate climate change create trade-offs, requiring a strategic and comprehensive approach. The measures proposed include the sustainable intensification of agricultural production at global level, the use of waste as a resource, and a radical change in consumption patterns in the EU. A Bioeconomy Panel has been created with the aim of enhancing coherence between policies, initiatives and economic sectors and creating an open dialogue on the research process behind the bioeconomy. A Bioeconomy Observatory has also been created to assess the progress and impact of the bioeconomy.

The US strategy

The National Bioeconomy Blueprint of the United States of America understands the bioeconomy as "an economic activity that is fuelled by research and innovation in the biological sciences". The technologies of specific interest here are genetic engineering, DNA sequencing, manipulation of biomolecules and the use of microorganisms or industrial enzymes, as well as the direct engineering of microbes and plants. Similarly to the EU Strategy, the US strategy expresses the wish to replace petrochemical products by bio-based products and thus mitigate climate change.

The US strategy recognises that, in the years to come, a growing population will require more food, while at the same time the availability of arable land resources is set to diminish. The response to this is the increase of crop yields by a combination of classical breeding techniques and biotechnology. It is said that yield increases have already been achieved through biotechnology-enabled pest control. A further aim is to enhance disease resistance and improve the nutritional value of food. Moreover, the strategy has a development policy dimension, referring to the activities of the United States Agency for International Development (USAID). Together with the Bill & Melinda Gates Foundation, the agency supports agricultural research designed to benefit smallholder farmers in developing countries.

The German bioeconomy strategies

The German National Research Strategy and the National Policy Strategy on BioEconomy cover all the sectors that develop, produce, process or utilise biological resources.

The research strategy focuses on gaining a better understanding of the elements and structures of biological systems, such as plants/algae, enzymes and microorganisms. Biotechnology is now applied in many different sectors: in the medical sector, in industry (fine chemicals and bioplastics), in the agricultural economy (pesticides, feed additives) and in environmental services (wastewater purification). A strong theme in the strategy is the need to strengthen interdisciplinary research (see also article on pages 14–15).

Both German strategy documents refer to food security as a priority. Like the European Commission strategy, the Policy Strategy emphasises the trade-offs that may appear between a number of goals: securing food, replacing fossil-based raw materials, protecting the climate by using renewable raw materials efficiently, conserv-

What do we mean by "bioeconomy"?

The strategies use either the terms "bioeconomy" or "bio-based economy", and these terms are often used interchangeably. **Bioeconomy** is characterised by economic activities deriving from scientific and research activities that are linked to different forms of biotechnology. It turns life science knowledge, meaning the scientific study of living organisms, into sustainable, eco-efficient and competitive products. The term "bio-based" refers to the primary material from which products are produced. The "bio-based economy" usually includes all sectors that develop, produce, process or use plants, animals or microorganisms. Strategies using the term "bio-based" cover all sectors using biomass, from primary production sectors, like agriculture and forestry, through traditional sectors using biomass, such as wood-based construction, to modern sectors making use of biotechnology. A bio-based industry would largely replace fossil-based raw materials by renewable raw materials.

The term **green economy** is sometimes used in close relation to the bioeconomy. According to the UN Environmental Programme, "a green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities." The bioeconomy and green economy share a number of characteristics, such as resource efficiency and low carbon dioxide release, but they are not fully congruent. The green economy may make use of bio-based products, but it is not limited to these. Renewable energies, such as wind and solar energy, can also be important contributors to the green economy while not being bio-based.

Photo: GIZ/W. Jarupun

Palm oil, being a sought-after raw material for the biofuel industry, is also an interesting source of income for farmers in the South. But the associated large-scale conversion of land that has also caused wide areas of rain forests to be clearcut has brought on much criticism.

ing biodiversity and soil fertility, and securing and creating employment. Conflicts may appear due to competing claims to land-use for the production of food, feed and renewable raw materials for energy and industry. It is stressed that the import of biomass to Germany should not create negative social, economic and environmental consequences in producer countries. A number of measures supported at international level aim at the intensification of agricultural production, the reduction of food waste, use of co- and waste products and changing consumption patterns.

Russia

The State Coordination Programme "Bio 2020" was drawn up under the auspices of the Ministry of Economic Development of the Russian Federation with the participation of a wide range of other ministries, agencies and academies. The bioeconomy embraces all economic sectors that use renewable resources, including the medical sector, agriculture and food processing, forestry and fisheries as well as environmental protection. Consistent with other strategies, life sciences are considered as the basis for designing new materials, increasing agricultural productivity and protecting the environment.

As in the EU strategy, the technologies of special interest are nanotechnology and information technologies. A number of academies will be involved in the relevant research efforts in various fields, and three technological platforms have been formed: "Medicine for the Future", "Bioindustry and Bioresources – BioTech 2030" and "Bioenergy". These platforms aim at harmonising the interests of various stakeholders.

The Russian strategy mentions that the Russian Federation has an almost unlimited availability of renewable raw material resources. This is probably the reason why food security is of no concern. The only aspect connected with food security is food safety. The strategy considers the application of biotechnology in the agricultural and food sector as an approach to enhancing food safety.

Argentina

Argentina has not developed a separate bioeconomy strategy, although some sectors applying biotechnology fall under the national plan "Argentina Innovadora 2020". The Argentinian Ministry of Science, Technology and Innovation defines the bioeconomy as an economy that uses biomass in an integrated and sustainable way for the processing of food, biofuels, thermal energy, chemicals and other materials. Having such a strong agricultural sector, Argentina places the emphasis on biotechnology in farming and food processing, although red biotechnology (vaccines and biosimilars) also plays an important role.

The goal is to achieve genetic improvement of food plants as well as technological advances in food processing with a view to increasing the quantity and nutritional quality of food products. Argentina seeks to increase its food exports and, in addition, develop various bio-based industrial products. The focus here is on bioenergy, biopolymers and chemical components. Argentina is already one of the largest producers of genetically modified soy, maize and cotton. It is active in research on genetically modified potatoes and other food crops. Some public concern about the large-scale use of herbicides in connection with genetically modified foods has arisen there in recent years.

India

The Ministry of Science and Technology of India drafted a National Biotechnology Development Strategy in 2007, which was updated in 2014. It uses the term "bioeconomy", which it understands as "translating life sciences knowledge into socially relevant ecofriendly and competitive products". It applies biotechnology in agriculture, health, energy, the environment and bio-manufacturing. The red biotechnology sector dominates the Indian biotechnology market and specialises in the production of vaccines and diagnostics.

Interestingly, the 2014 strategy paper contains a full chapter on Food and Nutritional Security, which largely deals with (bio)fortification of food crops to address micronutrient deficiencies, such as iron deficiency. The idea is to

develop special food products that can address moderate and acute child malnutrition. It is hoped that new processing techniques, including nanotechnology applications, will extend the shelf life of foods.

India is cultivating genetically modified cotton varieties on eleven million hectares of land. It is continuing its testing of rice, mustard, rubber, sorghum and peanuts, although no genetically modified food products are currently authorised for commercial cultivation. The country is planning further research into transgenic crops capable of resisting biotic and abiotic stresses. India aims to use 20 per cent biodiesel in its fuel mix by 2025, but seeks to avoid a conflict between food and fuel production. Research into jatropha cultivation on degraded soils is still ongoing, although this work is not included in the current Biotechnology Strategy. Rather, the strategy highlights lignocellulosic ethanol produced from agricultural and forestry waste, as well as biofuels from algae.

Malaysia

In Malaysia, a National Biotechnology Policy was drafted in 2005. It is a long-term policy through to 2020 and split into individual phases. The aim is to transform Malaysia into a high-income, inclusive and sustainable economy. It led to the creation of a Bioeconomy Transformation Programme in 2012. It is a platform provided by the government for the private sector to maximise commercial opportunities based on biotechnology. The policy has also established BiotechCorp (Malaysian Biotechnology Corporation), a one-stop centre for biotechnology, as well as three national research institutes.

The agricultural sector contributes significantly to the national economy in Malaysia. Bio-based farm inputs, feedstock additives, high-value food varieties and the development of novel livestock and aquaculture play a strong role. Nevertheless, to date, no genetically modified crops are authorised for commercial purposes. Malaysia is the second largest producer of palm oil. While demand for palm oil is rising, Malaysia is trying to halt further land conversion for palm oil production. So research has concentrated more on increasing yields. In 2013, a research team deciphered the full genome of the oil palm *Elaeis guineensis*, which helps select the most productive variety at an early growing stage. Furthermore, residues from palm oil production are transformed into cellulosic ethanol.

What role for food security in bioeconomy strategies?

Bioeconomy strategies approach food security in different ways. In most cases, biotechnology is regarded as a promising way to increase yields, improve food safety and the nutritional quality of foods. These aspects are frequently considered sufficient to make a contribution to food security, with little attention given to changes in consumption patterns and efficiency in the use of resources. Yet, in a few strategies, the increased demand for non-food biomass is explicitly named as a potential threat to food security. In India, for example, policy on support for biofuels is conscious of potential land-use conflicts.

The increased use of land and other natural resources as well as the widespread modification of plants for human benefit mean a significant intervention in living organisms with likely impacts on (natural) biodiversity and the functioning of ecosystems. However, most strategies highlight potential benefits to humans and the environment to the greatest possible extent, while making only brief mention of safety risks linked to the modification of biological organisms.

Bioeconomy-related actions and strategies (selection)

Argentina	National Plan "Argentina Innovadora 2020" (2012)
Austria	Bioeconomy Background Paper (2013)
Australia	Bioenergy – Strategic Plan 2012–2015
Brazil	Biotechnology Development Policy (2007)
Canada	Blueprint beyond Moose and Mountains (2011)
Denmark	Agreement on Green Growth (2009)
EU Commission	A Bioeconomy for Europe (2012)
Finland	Finnish Bioeconomy Strategy – Sustainable Growth from Bioeconomy (2014)
Germany	National Policy Strategy on Bioeconomy (2013) National Research Strategy BioEconomy 2030 (2010)
Great Britain	UK Bioenergy Strategy (2011)
India	National Biotechnology Development Strategy (2007/2014)
Ireland	Delivering our Green Potential (2012)
Japan	Biomass Industrialization Strategy (2013) Biomass Utilization Plan (2009)
Malaysia	National Biotechnology Policy (2005) Bioeconomy Initiative and National Biomass Strategy 2020 (2011)
Netherlands	Bio-based Economy 2010–2015
Russia	Bioindustry and Bioresources – BioTech 2030 (2012)
South Africa	South Africa – the Bioeconomy Strategy (2013)
Sweden	Research and Innovation Strategy for Bio-based Economy (2011)
USA	National Bioeconomy Blueprint (2012)

Research: Global co-operation for locally optimised solutions

Sustainable bioeconomic production means that biomass is processed, refined and transformed directly where it grows. At the same time, one of the main objectives of the bioeconomy is to tackle global challenges. Germany's Federal Ministry of Education and Research is therefore promoting, in addition to national and European initiatives, projects in countries outside Europe that are designed, in partnership with local actors, to find locally optimised solutions.

Rural regions hold the key to structural change in the direction of a bio-based economy. On the one hand, rural regions are critically important in terms of growing sufficient biomass to supply the population with food and regenerative raw materials. On the other, the bioeconomy offers the rural regions opportunities to establish new industries, thereby creating new income and stabilising food markets. To support the vision of a sustainable bio-based economic system, Germany's Federal Ministry of Education and Research (BMBF) fosters carefully targeted research activities. To this end, it has launched a number of funding initiatives under the German government's "National Research Strategy BioEconomy 2030".

The BMBF research strategy

Securing food supplies worldwide has top priority in a sustainable bioeconomy. To ensure that enough food will be produced in future we must not only raise agricultural output but also avoid post-harvest losses, which demands consideration of the entire value chain – from breeder to consumer. It is of paramount importance that increases in agricultural output are achieved sustainably, in other words in line with the imperatives of environmental protection, climate change mitigation, resource availability and biodiversity conservation. The sustainability aspect is of particular concern to rural areas where it is vital to safeguard natural resources.

The quantity of food is, however, only one side of the food security question. Consumers also expect quality: food that is healthy, safe and affordable. Eating habits are being shaped by shifting demographics and economic conditions, especially in developing and industrialising countries with fast-changing lifestyles and living conditions. A healthy diet assumes that healthy and safe food is produced and meets individual's expectations.

In addition to supplying the population with sufficient and healthy food, the rural areas should also be providing renewable raw materials for industrial use and for energy generation. We can make bio-based products that not only alleviate pressures on the environment, nature and the climate but also help to reduce our dependency on fossil fuels. To overcome potential conflicts between the use of plants for food and their use as a raw material for industry, the research is now, for example, looking into ways of exploiting the inedible components of plants as a source of raw materials. One solution might be what is called a multiple or cascading use of biomass (see article on pages 28–29). Again, consideration must be given here to treating natural resources like soil, water and nutrients in a sustainable manner.

A bioeconomy can only be implemented with the active participation of society and with due regard to all aspects of the industrial transformation that it entails. In the BMBF's action plan ("Wegweiser Bioökonomie") for the second half of its research strategy, the ministry has therefore drawn up four guidelines. First, we need to build greater expertise in the systemic approach to bioeconomy, one that integrates the natural, engineering and social sciences. Second, the BMBF wants to establish an open culture of communication and responsibility and foster a participatory discourse, bringing together actors from the spheres of research, industry, society and government. Third, the bioeconomy strategy needs stronger roots in industry, and to this end we are trying to create the intelligent spaces for innovation needed to develop bio-based products, methods and services. And last, but not least, thought must be given to incentives for more people to enter the field and meet the need for specialists and skilled human resources in a bio-based economy.

Bioeconomy as a global concept

The bioeconomy is a response to the major global challenges of the 21st century – the need to feed the world's expanding population in conditions of accelerated climate change and disappearing natural resources and the need to move away from our dependency on fossil fuels. Hence, the bioeconomy can only be realised within a global context and through international co-opera-

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Photo: J. Boethling

Co-operation with research institutions from different regions across Africa is an integral part of the GlobE research initiative.

tion. Collaboration on research and development is vital if we are to exploit the synergies that exist, especially between the industrialised world and the developing and emerging economies. These partners from both parts of the world can contribute their specific potentials, resulting in opportunities for complementing expertise and sharing know-how. This is why our bioeconomy research strategy is a national research strategy with a strong international orientation.

GlobE – food security through sustainable agriculture in Africa. In view of these requirements, the BMBF has initiated a research initiative entitled "GlobE – Securing the Global Food Supply". Starting from an analysis of regional needs in Africa, "GlobE" projects identify and tackle research topics at all levels of the food production system. The integration of and co-operation with research institutions from the different regions across Africa is an essential aspect of the initiative. This collaboration allows us to determine regional requirements and address the existing challenges on the basis of a shared understanding and a needs-oriented approach. Thanks to this funding programme we are able to build bridges between developing and industrialised countries, between traditional cultivation techniques and highly developed crop systems, without displacing the knowledge and expertise of the developing countries. On the contrary, our idea is to foster reciprocal scientific exchange to the benefit of both the African and the German partners.

Global food security requires us to support efforts in the various regions of the world to establish an efficient and sustainable agricultural system in places where food supplies are most vulnerable. This applies above all to parts of the African continent. Due to a range of factors there are rural areas in many African countries where yields are often too low for viable and sustainable farming. Some of the core issues for research conducted under this funding initiative therefore include developing appropriate cultivation methods, reducing harvest and post-harvest losses and creating greater resilience of agricultural production in the response to particular stresses.

Bioeconomy International – research collaborations between equal partners. "Bioökonomie International" is a broader-based initiative. It involves close collaboration with partners from non-European countries who work with us on an equal footing. These research and development projects address central issues of the overall bioeconomy strategy. Partnerships with the South have been forged in Asian countries, such as Malaysia and Vietnam, as well as in Argentina, Chile and Brazil in South America. Each partner has special competencies, resources and infrastructures to contribute, so important cross-national synergies can be generated. To simplify procedures for potential project partners, the BMBF is working closely with education and research ministries in some of the partner countries. The "Bioökonomie International" scheme can, in principle, fund projects from any fields within the BMBF's bioeconomy research strategy, but we tend to set priorities, in agreement with individual countries, that match their specific potential and needs. For instance, co-operation with Argentina is primarily focused on the areas of sustainable agriculture and biomass production, while in the case of Brazil research into the industrial exploitation of regenerative raw materials is particularly important.

Looking to the future

The extent to which the strategic objectives and the individual funding initiatives of the government's research strategy will make the desired contribution to a bio-based and sustainable economy will be analysed at the end of the funding period by external evaluation. The knowledge and experience gained from the research and the wider social dialogue will provide the foundations for a future funding programme that will help secure sustainable and bio-based growth in Germany.

The value web approach – so that the South can also benefit from the bioeconomy

The rising demand for biomass is transforming agriculture from a food to a complex biomass-supplying and -processing sector, which the countries of the South could benefit from. New prospects could arise for them to go beyond their role of pure raw material suppliers. However, a value chain approach is insufficient in this context. The biomass-based value web appears to offer an alternative approach.

The increasing global demand for biomass, as primary agricultural products and feedstock for various forms of usage, has started to change the global agricultural production and price structure. Studies conclude that the high demand for biofuels in the USA and European Union was the most crucial factor for the emergence of the food price crisis in 2007/8.

However, on bioenergy's coat-tails, biomass demand for other uses has increased: Substituting biomass-based products for crude oil-based products in various industrial areas is – if not yet in mass-production – in its experimental phase. For instance, the market for biomass-based plastic is growing. The Coca-Cola company is already using 30 per cent biomass-based PET plastic, while Toyota and other car brands have started to replace oil-based plastic for cars with bioplastics. This rise in global biomass demand is an opportunity for many agricultural-based, low-income economies to diversify their economy. Yet, concerns prevail that producing more and diversified non-food crop biomass commodities will compete with domestic food production and perpetuate these countries' status as mere suppliers of raw materials. Three strategies may counter these concerns:

1) The countries involved have to ascertain the priority of ensuring or improving the status of food security at national, regional and local level while taking advantage of emerging bioeconomies world-wide. To achieve this, the focus should be on labour-intensive, job-creating crops, production and processing. Another approach is the certification of the production of all types of biomass (food, feed, fuel, fibre, etc.), whether exported or nationally used, for not being in conflict with food and nutrition security, preferably in combination with a global monitoring of the impact of non-food biomass use on food security.

2) The agrarian-dominated economies will benefit significantly more from the increasing demand for biomass if major parts of the value addition to the raw product "biomass" take place domestically in a labour-intensive processing sector.

3) To prevent excessive pressure on natural production resources, a sustainable productivity increase has to be part of the emerging bioeconomy, partly through sustainable biomass production intensification, but also through efficiency gains in all required post-harvest, processing and trading activities.

The old dilemma: biomass only becomes valuable through processing

Where and how much value is best added to biomass-based products is an old discussion within the development community. Even today, the majority of low-income, agrarian-dominated countries are not fully exploiting processing opportunities for their biomass-based products exported to other countries.

The **cut-flower** industry in Eastern Africa is a good example of how value addition through processing (mainly handling in this case) can take place in the country of biomass production. Due to high labour requirements

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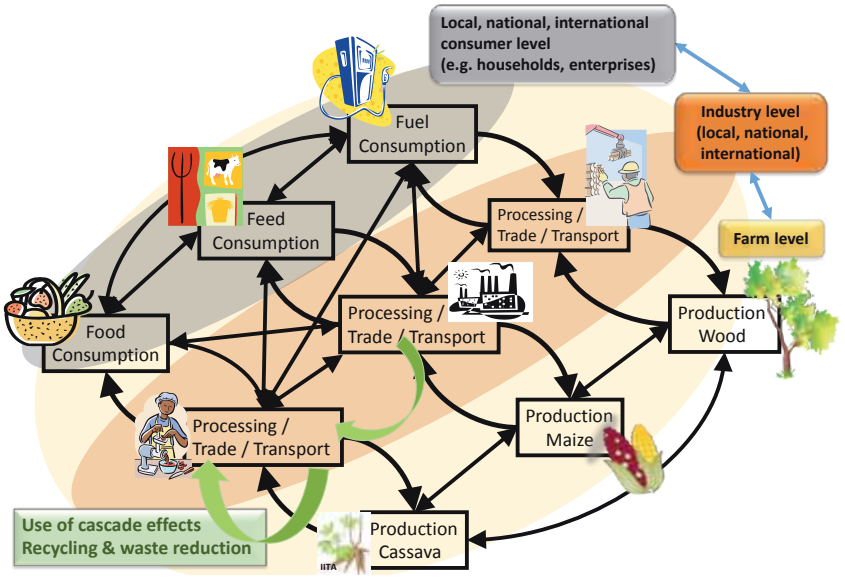
Various automobile manufacturers have started to replace oil-based plastic with bio-based plastic – for example Mercedes-Benz chose the EcoPaXX polyamide produced by the Royal DSM Company for the engine beauty cover of the latest version of its A-Class family car.

Photo: Royal DSM

Simplified biomass-based value web



in the process, the local communities benefit from income earnings of locally hired workers. **Coffee** is an example where value addition through roasting fresh coffee for export is difficult in most producing countries. The national preferences regarding the type of roasted coffee are too diverse across customer countries, and roasted coffee cannot be stored for long time. However, regarding soluble (instant) coffee, several producer countries like India, Brazil, Thailand and Ecuador process coffee nationally and market up to 60 per cent of their total coffee exports as instant coffee. **Cotton** production and processing shows a more diverse picture: India, with the largest cotton cultivated area (about 30 % of the global cotton production area), has long had a strong textile industry employing up to 50 million people in cotton processing and trading, besides nearly six million farmers in cotton production. West Africa's cotton production has expanded over the last decade without the development of a significant domestic textile industry.

The crucial and most significant value addition in the international bioenergy value chain is taking place in the countries importing biomass for bioenergy utilisation. The biomass-exporting countries are not significantly upgrading their biomass before exporting. This tendency will most likely advance with the third and fourth generation of bioenergy sources and especially with further advanced processing technologies like biorefineries, which can efficiently use plant raw materials for processing as well as for energetic purposes, especially as residual materials from diverse sources can be used. For example, "integrated forest biorefineries" can be added to an existing pulp mill, as piloted in the USA. In addition to pulp and paper, the complex also produces renewable energy (heat, electricity and liquid fuels) and bio-products like special chemicals and other high-value materials from various sources of forest, low-cost agricultural materials and residues. Already today, modern pulp mills paving the way into such technology efficiency are net energy producers. The concept of bio-refineries is still in its infancy. Although the economic potential of bio-refineries has been realised, the conception and technology of a biorefinery has to be very precisely calculated before implementation. It includes a continuous provision of biomass to be processed and a well-established market for the processed products.

However, the more sophisticated the technologies, the higher the necessary investments in research and plant establishment are, the less likely that low-income, biomass-producing countries are able to incorporate these technologies and processing levels into their value addition processes of converting raw biomass into high-value materials. Reasons for the very limited value addition taking place in biomass processing in low-income, agrarian countries include a lack of technical infrastructure, skilled workers, and (national) financial instruments as well as an underestimation of the potential value of biomass products.

Broadening the approach: from value chains to value webs

The complexity of value chains of agricultural products is increasing significantly. With the evolving bioeconomy, especially the demand side for different biomass types will be branching out with impacts at the handling, processing and trading level leading to an augmented diversity of activities. The example of a modern pulp mill stated above demonstrates the growing complexity. This bio-refinery will adjust both the quantity (and quality) of the diverse biomass sources as input and the produced output depending on biomass availability and demanded products as well as the relevant prices, thereby optimising the plant's profit. The rising demand for food and non-food biomass transforms agriculture from a food to a biomass-supplying and -processing sector in which the utilisation of the various feedstock crops and intermediate products is more flexible than it was in the past. Part of this development is that especially at the processing and trading level, the recycling and cascading effects to utilise and reutilise biomass at a very high degree ("zero waste") will lead to merged value chains. Hence, it is no longer sufficient to analyse the system by following the conventional more (isolated and) linear, mainly product-focused value chain approach. Analytical perspectives are needed which cover the complex pathways of biomass which include but go beyond the concept of value chain analysis. Here the holistic concept of biomass-based value webs becomes instrumental.

A biomass-based value web approach utilises the 'web perspective' as a multi-dimensional framework to un-

derstand the interrelation and linkages between several value chains and how they are governed. Instead of depicting the pathway of one product and thus being in tendency more industry-oriented, the web approach captures the manifold products which are and can be derived from one biomass raw product and respectively looks at the whole product mix produced on family farms, the different value chains the households participate in and how they are and could be linked. The web perspective helps to explore synergies between these value chains, identify inefficiencies and pinpoint potential for sustainable productivity increases in the entire biomass-based value web of a defined local, national or international system. This includes the analysis of existing and potential recycling processes and cascading uses during the processing phase of biomass, which opens new opportunities to locally capture more of the value-added. The cascades of use and interlinking of value chains are instrumental to increase the efficiency of resources and the sector, reduce possible areas of competition between uses and to make use of innovation potential.

The web perspective also helps to better identify who participates and benefits in the value webs (e.g. men or women, small or large producers/processors, national or international actors) and who does not, in which activities and processes, and whether and how the actors co-operate and network with each other. This helps to identify missing links and actors needed, information gaps, and capacity constraints as well as governance issues and power relations. The analytical approach also contributes to identifying profit and other benefit distributions among the different actors and participants in the whole web. Thus, opportunities can be detected how and where more value could be captured in poor producing countries, how it could be more equitably distributed and where access to food through job and income generation can be increased.

Increasing the activities of the domestic processing industry for biomass products requires the political commitment of governments as well as international support. Technical and physical infrastructure, a skilled labour force, and financial instruments are part of the solution. Further research and investment in labour-intensive yet capital-saving processing technologies for biomass commodities in developing countries is important. In the long term, a sustainable domestic processing and value addition will also require that domestic demand and markets develop.

The emerging bioeconomies may help low-income, agrarian-dominated countries to generate jobs and income in the biomass producing, processing and trading sector, particularly in rural areas. The key challenges are to identify ways for poor countries and poor producers to take advantage of these opportunities, which types of biomass, processing and technologies offer a realistic chance for biomass producers and processors in these countries and how, at the same time, food security can be enhanced and poverty reduced. Further knowledge gaps exist where the respective value chains and value webs need adjustments and support to ensure that value addition not only stays in the producing countries but also contributes to improving the livelihoods of family farmers, to foster small and medium-sized processors and generate employment opportunities.

A biomass-based value web for Africa

The BiomassWeb project "Improving food security in Africa through increased system productivity of biomass-based value webs" provides concepts to increase the availability of and access to food in sub-Saharan Africa while attending growing demands for non-food biomass. The research project identifies biomass-based value webs and studies selected entry points to increase overall system productivity. This includes exemplary agronomic, technological and institutional innovations in production, processing, and utilisation of biomass-based goods to market more and higher-value food and non-food biomass. The concept is based on innovation system approaches, stakeholder participation, demand-driven research and development activities. The research region is the productive Sudanese savanna belt (Ghana, Nigeria) and the East African highlands (Ethiopia). Specific exemplary 'model' value webs will be studied based on cassava, maize, banana/plantain/enset and biomass derived from natural vegetation and agroforestry systems. The project is funded under the BMBF initiative GlobE (see pages 14–15).
For more information: ➤ **www.biomassweb.org**

Photo: M. Denich

The project also examines how small-scale farmers' typical diversified cropping systems can be integrated into a value web approach.

Tailoring the bioeconomy to food security

Bioeconomy strategies can contribute to poverty reduction – provided that they are circumspectly designed. Binding regulations are needed guaranteeing that the human right to adequate food is not threatened. Sustainability standards only make sense if the primacy of food security is not only formally integrated in them but is also anchored by verifiable criteria.

A few years ago, the European Union and the United States of America took a crucial step towards the bioeconomy by deciding to introduce and promote biofuels. This political target has led to a broad public debate on "food before fuel". While politicians, bioenergy associations and environmental and development organisations are still struggling for a compromise on biofuel quota, the use of biomass has increased almost unnoticed in other sectors. Here, possible impacts on global food security are seldom examined. For example those of bottles made of bioplastics gained from sugar cane. Or bio-dowels based on castor oil. Neither is the question raised how our cows are going to graze when rubber is gained from dandelion milk for our winter tyres in future. Of course we want to bid farewell to an economy centring on the environmentally harmful use of fossil resources. The use of biomass is an important element of an ecologically sustainable mode of economy – not only in the energy sector. But just like with biofuel, for any use of biomass for non-food purposes, it is essential to make an optimally accurate assessment of the global impacts and guarantee the primacy of food security. To this end, forward-looking and binding political guidelines are just as important as prudent entrepreneurial action.

Global dimension often underestimated

Today, every third human being is still suffering from hunger – 842 million people world-wide. At least 70 per cent of them live on agriculture in the rural regions of the developing countries. Through the transition from the fossil economy to the bioeconomy, these regions, which are especially hard-hit by poverty and hunger, will tremendously gain in importance. Together with water, solar radiation, heat and cheap labour, their fertile soils offer ideal cultivation conditions for the production of biomass. Without the use of these resources, the implementation of the European and German bioeconomy strategies is hardly conceivable. Already today, Europe's cropland is no longer sufficient, and the EU requires an additional 25 million hectares of agricultural area abroad to cover its demand for agricultural products (Noleppa, v. Witzke and Cartsburg 2013). This corresponds to the area of Great Britain. The transition to the bioeconomy is going to further raise the demand for agricultural commodities, and in developing countries in particular, it will have a massive impact on agricultural production based on smallholdings.

The implementation of the exaggerated biofuel targets has shown us that in spite of legal environmental provisions, fuel crops are not only exacerbating the excessive exploitation of nature but that indirectly, they have triggered severe social maldevelopments. In many places, land-grabbing in developing countries and strong increases in food prices are plunging poor people into hunger. In biofuel policy, it is in particular the social impacts that have been eclipsed for too long. This is one of the reasons why biofuels are seeing such a low level of acceptance in society. What counts now is to learn from these wrong decisions and developments and design the production of biomass especially in the developing countries in a manner that will ensure a contribution to food security and poverty reduction.

Even now, Europe does not have enough land to cover its demand for agricultural products. The transition to the bioeconomy massively increases this demand.

Photo: Bilderbox.com

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Photo: J. Boethling

Delivering sugar cane for energy production on the Philippines. The biofuels policy of recent years and the resulting boost in demand for raw materials has led to an expansion of plantations and largely excluded rural agriculture.

Developing a pro-poor bioeconomy

Prudently conceived bioeconomy strategies can contribute to poverty reduction both at global and local level. They can do so globally because in the EU or the USA, for example, less farm surpluses are accumulated that are sold to poorer countries at dumping prices and make smallholder agriculture there unprofitable. Also, the bioeconomy can contribute to combating global warming, which is particularly important for smallholders. They live in regions that are especially hard-hit by the consequences of climate change, without having caused it. Lastly, modern use of biomass points to options that developing countries can seek to largely leap-frog the fossil economy stage.

However, it is particularly important to take advantage of the demand for biomass to reduce poverty in poor rural regions. Across the world, more than 400 million smallholdings can be integrated in biomass production. This is precisely what failed in biofuel production. High demand has resulted in an expansion of plantations and largely excluded rural agriculture. What is needed is a bioeconomy policy promoting a gentle increase in the demand for biomass. Smallholders must have time to get reorganised, e.g. in producer groups and co-operatives. Cultivation methods and market access need to be improved. These processes take time, time needed to develop impoverished smallholdings towards farms whose production is economically viable and socially and ecologically sustainable.

Taking the human right to food into account

Already in 2004, the United Nations agreed on guidelines for a right to adequate food containing a paragraph on "International co-operation and unilateral measures", which also says that:

"States are strongly urged to take steps with a view to the avoidance of, and refrain from, any unilateral measure not in accordance with international law and the charter of the United Nations that impedes the full achievement of economic and social development by the populations of the affected countries and that hinders their progressive realization of the right to adequate food."

A commitment can be derived from this appeal, which is supported by all UN members, to not only examine possible national impacts in using biomass for non-food purposes but also assess what effects they could have on other countries. The introduction of a "policy impact assessment on global food security" could ensure that possible desired and undesirable consequences of policies for global food security are explicitly debated in political parliamentary deliberation and decision-making processes before decisions are taken. In Germany, this would, for example, mean that the existing procedure of legislation impact assessment be extended by the component of "international responsibility", with a special focus on possible consequences for food security. Moreover, taking the global dimension into account in legislation impact assessment would lead to greater coherence between all domestic and foreign policy fields.

Introducing minimum standards for biomass

The bioeconomy strategies of the EU (2012) and the German Federal Government (2013) ensure that the primacy of food security is taken into account. As yet, however, no scientifically based standards and benchmarks have been introduced that would allow for examining whether the human right to food is taken into account in the production and use of biomass. So far, provisions have only been made for a certification of biomass used for fuel purposes, i.e. certified palm oil has to be filled into the petrol tank while the non-certified oil is for on the plate (e.g. as margarine) or on the skin (e.g. in cosmetics). In addition, the biofuel criteria hardly consider social aspects. Appropriate legislation is necessary but is currently being planned neither at national nor at European level.

The transition to the bioeconomy contributes to the clear division between biomass being used for food, fodder, energy or industry being blurred, since the markets are increasingly overlapping. This is why a global

biomass standard is required that regulates the production of all types of biomass for their various areas of use (food and fodder, energy and materials) at cross-country and cross sector level. Here, both ecological and economic and, above all, social sustainability criteria have to be integrated. Only then can it be ensured that non-food use of biomass does not endanger the human right to food. In introducing standards, it has to be ensured simultaneously that they do not turn into a development obstacle. Two risks must be considered in particular here:

1) If the cultivation of biomass meets strict sustainability criteria without making a contribution to local development in the context of the production chain as a whole, the factual state of poverty and hunger is accepted. In the worst case, poverty is thus both tolerated and certified.

2) If the demands on biomass production with regard to environmental and social standards are too high, smallholders will be systematically excluded owing to their low investment potential and cannot benefit from the emerging bioeconomy.

Establishing food security as a binding criterion for sustainability

So far, only few proposals have been made on assessing food security aspects in the use of biomass. The Roundtable on Sustainable Biomaterials (RSB) has proposed a guideline for food security assessments as well as criteria for an improvement of the local food situation (2012). However, because of its extremely complex assessment methods, this comprehensive guideline has not found significant use in practice. Neither have the manuals issued by the Food and Agriculture Organization (FAO–BEFSCI) and the Global Bioenergy Partnership (GBEP) been applied practically. Moreover, existing standards tend to be more applicable for large-scale enterprises (incl. plantations) and do not consider the options that smallholders have for their implementation, so that there is a danger of systematically excluding smallholders. The demand for manageable food security criteria has been discussed from various angles in the context of the German Federal Government's "Initiative Sustainable Supply of Raw Materials for the Industrial Use of Biomass" (INRO). Government authorities and certification agencies, research institutions, environmental and development NGOs, and in particular businesses have criticised this omission in the various standards and certification systems.

The Center for Development Research (ZEF) at the University of Bonn in Germany and Welthungerhilfe have set themselves the task of filling this gap and developing scientifically sound criteria for food security based on the human right to food and the four pillars of food security (availability, stability of supply, access and utilisation). In practice, this means considering and implementing the Voluntary Guidelines on the Human Right to Adequate Food.

The aim of the project is to provide manageable standards

- that contribute to continuous improvements in the local food situation; this is achieved in particular by a better income situation in the growing regions, which also includes the sale of biomass,
- that offer smallholders and medium-sized farms the opportunity to meet rising requirements step by step,
- that commit large-scale enterprises to act as drivers of development,
- whose implementation is made flexible enough to be able to act in accordance with local conditions without watering down the standards to be achieved,
- that generate progress and socio-economic development.

The production of biomass has to meet the priorities of the people in the growing regions and contribute to adequate living standards in the long run. In an interdisciplinary context, development criteria are to be developed that consider the standards of science, civil society, politics and also businesses. The aim is not to introduce most demanding criteria overnight, but to be able to implement successively higher social standards.

More and more non-food products are being produced with agricultural raw materials. Biofuels policy has failed to perform the balancing act between non-food use of biomass and the creation of global food security. But it is precisely this balance that is needed if the transition to a bioeconomy is to be sustainable. The degree of taking the human right to adequate food into consideration both in policy design and in entrepreneurial action is going to be crucial to whether bioeconomy strategies will impede access to food for poor people or, in the favourable case, contribute to combating poverty.

Photo: J. Boethling

Bioeconomy strategy designs have to avoid threatening food security, particularly of small-scale farmers.

“To make the change happen, the key is to work together in partnerships”

How does industry view the future of the bioeconomy? An assessment by Dr Marcel Wubbolts, Chief Technology Officer of the Dutch-based multinational company Royal DSM.

Mr. Wubbolts, why does your company operate in the field of bioeconomy?

By the year 2050, the world population is forecast to reach nine billion people. It will become increasingly difficult to meet the needs of so many for feed, food, energy and materials from this single planet. In order not to compromise the prosperity of future generations, DSM is convinced that today we must start finding alternatives for our long-lasting reliance on oil and other fossil resources, with their significant impact on the environment, and make the transition to renewable energy sources, chemical building blocks and materials. Switching our economic system to plant-based, rather than relying on – finite – fossil resources, will offer energy security, lower carbon emissions, sustainable economic growth and availability of resources. It opens opportunities for sustainable agriculture that will provide food, feed, energy and materials. DSM’s ambition is to take a leading position in a new bio-based economy by helping to realise the full sustainability and commercial potential of biofuels and bio-based chemicals and materials. We believe we can create brighter lives for people today and generations to come.

What are the most important bio-based products in your range of articles?

DSM is a biotechnology pioneer that has been acquiring knowledge and expertise in this area since the 1870s. In our work, we operate at the interface of energy and agriculture – the two largest industries in the world. At this crucial intersection, we have come to specialise in turning plant-based feedstock into chemicals and materials of all kinds, and breaking brand-new ground in (ligno-cellulosic) biomass conversion. We are determined to reduce the world’s dependence on oil and fossil fuels, and in order to do so, we also collaborate with leading bio-entrepreneurs and industries. DSM is a full technology player in this sector, serving the needs of future bio-refinery owner-operators. We offer a designed cocktail of enzymes to break down (hemi-) cellulose from agricultural residues to simple C5 and C6 sugars. It also includes proprietary recombinant yeast, capable of co-fermenting the sugar mix for the production of cellulosic bio-ethanol, and advanced microbes for the production of microbial diesel. In the field of bio-based chemicals and materials, DSM works along the value chain with agriculture (feedstock providers), (petroleum based) incumbents and/or downstream users. For these customers, we have developed a novel low-pH fermentative route to produce Biosuccinium – a high quality, bio-based version alternative for conventional fossil chemicals such as succinic acid and adipic acid with a better environmental footprint. This product is manufactured and commercialised by a joint venture that has been created together with our business partner Roquette. In addition to Biosuccinium, DSM is exploring new bio-based routes for other bio-based platform molecules.

Another interesting product is the green polyamide EcoPaXX, with a bio-based content of about 70 per cent. It is a high performance engineering thermoplastic and is well suited to a wide range of, amongst others, automotive applications. Its combination of strength and stiffness, along with chemical and high heat resistance, makes it ideal for demanding under-the-hood components applications. With EcoPaXX, we’re bringing a new dimension to green motoring in the form of a bio-based material that is truly sustainable. Its blend of properties enables EcoPaXX to compete with (and in some cases surpass) not only metals but other plastics. Several interesting applications have recently been commercialised. For example, Mercedes-Benz chose EcoPaXX for the engine beauty cover of the latest version of its A-Class small family car, and the fuel vapour separator of Ferrari and Maserati is in EcoPaXX.

Photo: Royal DSM

Dr Marcel Wubbolts is Chief Technology Officer of Royal DSM.

How do you believe the demand for bio-based products is going to develop?

In a number of years, we will all be using a mix of natural, renewable resources for our energy needs – think of biofuels, but also of wind, solar and geothermal as energy sources. For our materials, we will be able to rely on bio-based renewable resources to a large extent. Because of all this, the pressure on our environment will become less, and we will move to a brighter future

with nine billion healthy people on one healthy planet. For this transition to succeed, we need a world-wide approach where stakeholders all over the world work together and where policy-makers will have to support the use of renewable resources for energy, materials and chemicals – in addition to food and feed – and where policy-makers start to discourage the unremitting use of finite fossil-based products for which sustainable alternatives are now available.

We are currently involved in a number of partnerships and joint ventures, in which we bring in our unique platform of conversion technologies. Our partners contribute their own expertise on biomass logistics, processing and market distribution. The challenges towards realising the change that we are after are enormous, and one company, institution or country cannot do this on its own. The key is to work together in partnerships to make the change happen.

One of these partnerships is the Bio-based Industries PPP project with the European Union. What are you expecting of your membership in this initiative?

The BBI is a new public-private partnership dedicated to breaking Europe's dependence on fossil fuels by converting biomass and wastes into greener everyday products. Innovative technologies and advanced bio-refineries are at the heart of this initiative, which focuses on deployment and the creation of new markets for bio-based products such as food, feed, chemicals, materials and fuels. I am Chairman of the Bio-based Industries Consortium, the private part in the PPP, and vice-chairman of the governing board of the PPP. As the private partner in this new endeavour, we are thrilled about having been able to translate the ambitions of multiple sectors into one coherent vision; and now, into concrete actions that place sustainability at the heart of all business activities. Without this partnership with the EU, industries across sectors wouldn't have taken the risk to invest in this emerging sector in Europe. The BBI is an achievement as such, but only the start of a long-term project where the combination of European, national and regional financing instruments will be essential to realise its full potential.

Have politicians chosen the right course regarding the bioeconomy, or do you believe there are things to catch up on?

When looking at the global market, Brazil and the US have policies in place – and already for years – that really aim to speed up the transition from fossil to bio-based. Other regions are catching up or at least are trying to catch up. The EU published its strategy 'Innovating for Sustainable Growth: A Bioeconomy for Europe' in 2012. A step in the right direction that is also reflected in the BBI–EU partnership. The next moves have to be to create policies that will help creating market pull. In this respect, US industry was able to speed up developments on biofuels when the US government put the RFS in place. The 'Renewable Fuels Standard' is a USA federal programme that requires transportation fuel sold in the US to contain a minimum volume of renewable fuels. Increasing amounts each year, escalating to 36 billion gallons by 2022. Each renewable fuel category in the RFS programme must emit lower levels of greenhouse gases relative to the petroleum fuel it replaces.

Do you procure the raw materials for your bio-based products exclusively from Europe?

Biomass is available around the globe, and we buy the raw materials for our bio-based products locally – close to our production sites. One example is cellulosic bio-ethanol: Our joint venture with the US ethanol producer Poet intends to globally license an integrated technology package that converts corn crop residue to cellulosic bio-ethanol to third parties, as well as the other 26 existing corn ethanol plants in Poet's network. Our Poet-DSM Joint Venture sources the raw material for Project Liberty – a commercial-scale, cellulosic ethanol plant in Iowa/USA for which preparations for start-up have begun this summer, from within a radius of about 30 miles around the facility. The plant is designed to produce approximately 25 million gallons per year.

Bioeconomy critics are concerned about negative impacts on food security. Do you also see this conflict?

The future is about food and fuel. Project Liberty is an example of this: it will make use of corncobs, leaves, husk, and some stalk that passes through the combine during harvest. The process uses about 25 per cent of the available corn residues, leaving 75 per cent on the soil for erosion control, nutrient replacement and other important farm management practices. Looking to the future of renewable energy, it's clear that the world's most abundant organic compound, cellulose, is most promising. It provides the cellular structure for trees, grass and all things organic. The plant will share infrastructure with the adjacent Poet Bio-refining in Emmetsburg/Iowa. Roads, land and other features will be shared, and the co-product from the cellulosic ethanol process will be energy, enough to power Liberty and send excess to the adjacent corn grain-based plant.

If you look at our EcoPaXX bio-based example, we are pleased to share that the three grades of EcoPaXX polyamide 410 from DSM have been given the ‚Certified Bio-based Product' label awarded by the United States Department of Agriculture. The grades of this high-performance engineering thermoplastic have a proven bio-based content of around 70 per cent. This is because the polymer incorporates building blocks derived from castor oil obtained from plants that grow in tropical regions and which are not used for food products. Furthermore, EcoPaXX has been shown to be 100 per cent carbon neutral from cradle to gate, which means that the carbon dioxide which is generated during the production process of the polymer is fully compensated by the amount of carbon dioxide absorbed in the growth phase of the castor beans.

More than just mediators

C.S.P. – Consulting and Service for plant-based raw materials GmbH, based in Dresden, Germany, aims to bring together supply and demand for bio-based resources. The potential is enormous, they believe, but so are the hurdles they have to face.

The C.S.P. team (f.l.t.r.): Marlene Hoppe, environmental engineer and project assistant, Evelin Tetzner, managing director, and Günter Gäbler, plant specialist and authorised representative. The team works with a network of international experts on its projects. Photo: S. Richter

Ms Tetzner, Mr Gäbler, where did you get the idea for your venture?

G. Gäbler: Nearly all over the world we see that farmers who grow renewable resources don't approach major industries on their own initiative. In most cases – at least in Europe and the USA – large dealers act as a go-between, either forcing manufacturers' price expectations on the producers, or speculating with the raw materials. On the other side are the industrial representatives who know nothing about agriculture, and who are not interested in questions of cultivation and harvesting. What they want is to have the resources delivered punctually so that they can integrate them in their production schedules – all year round. For various reasons the processing industry is not prepared to utilise large amounts of plant-based raw materials. Therefore we at C.S.P. aim to be the link between farmers and industry – with all the challenges and problems that entails.

What in particular are you thinking of?

G. Gäbler: Manufacturers will not come on board unless they have security of supply, which is often even more highly valued than price stability. They are accustomed to seeing prices fluctuate widely. But when they have converted their facilities to manufacture new products, it is not acceptable to them for a resource to be unavailable. This is the reason we decided to operate on a global scale from the start. If you have a single harvest each year – as here in Europe – and if this is inaccessible because of bad weather or because a competitor was quicker, claims for recourse can very quickly follow. Alternatives are needed within the financial year to compensate for the loss.

You act as mediators between agriculture and industry. Where exactly does your work begin and end?

G. Gäbler: It begins with the cultivation systems. When using biomass, particularly in an international context, the aim is to find plants and cultivation methods which do not negatively impact on local populations – especially in terms of food security. We look instead for solutions which expand the range – plants which can be industrially processed but at the same time improve soil fertility with their residual root mass. And enable the population to generate an additional income. This is why we also work on collaborative research projects such as the BiomassWeb. Our engineering and technology skills are also in demand. When it comes to transporting biomass you have a choice between two evils. Dried, uncompressed material involves hauling a lot of air around, whereas fresh mass contains a large proportion of water, which ends up costing more than the raw material itself. Furthermore, biomass is highly perishable. Consequently we need to find processes to compact and store such raw materials. As this is usually coupled with dehydration, the issue of energy automatically comes into play. Our core objective is to create sustainable loops whereby a large part of the energy needs can be met by the residues and wastes that arise in the processes. There are effective technologies for this, which can be used in a local, decentralised way that is appropriate to specific local conditions. We always seek to utilise residues at the first level of the recovery cascade, thereby meeting the heat and electricity demand of a facility or farm. Shaping such cycles effectively – and thus sustainably – is at the core of our company's work.

You also manage your own projects in Africa. Do you think that continent could profit from the current trend towards bioeconomy?

G. Gäbler: Absolutely. In many African countries it is "in" to build with concrete – those who can afford it are very highly regarded because cement is expensive. But if concrete construc-

tion does not meet high standards, the quality of air inside the house tends to be poor; the concrete insulates so well that mould can quickly form. The traditional method of construction uses earth bricks, but these are not at all durable, particularly in tropical climates. In 2010 we had an opportunity, more or less by chance, to discuss the matter with Ghana's then Minister of Construction. The mud-brick building style, traditional in many Asian and African nations, has significant – scientifically proven – advantages in terms of indoor air quality: air and condensation can diffuse well through the walls; moreover, mineralised plant fibres improve brick stability. And depending on the proportion of fibre, the structural elements weigh much less than concrete and often less than typical bricks. This makes a huge difference, particularly in rural areas where the entire family is usually involved in building a house.

Were you able to convince the Minister?

E. Tetzner: First of all we had to prove to her that the process really works. So we were suddenly faced with the task of looking for the appropriate materials and making a prototype. Among other things we used fronds of the oil palm, large quantities of which arise as waste. At first we integrated wood shavings and sawdust, but the Minister asked us to refrain from doing so. A few years before, the Ghanaian government had decided on a reforestation programme for its rainforest. She feared that it would be counterproductive to open up new sources of income to the timber mills by creating demand for wood shavings. It is vital that such regional conditions are taken into account when planning new projects.

Do you think that there is a general openness towards such projects?

M. Hoppe: There is always a great deal of interest when such examples are introduced at conferences and workshops. However, to the best of our knowledge there have only been isolated instances thus far. A large number of different plant-based resources could be used, and many approaches are being tested. Ultimately it is vital to carefully investigate the effect the fibre has on the building material, how it behaves and how it should be processed. Much research and development is still required, particularly if we plan to use it widely – in housing construction programmes, for instance.

E. Tetzner: A civil engineer at the University of Dar es Salaam in Tanzania has developed hollow blocks by embedding empty plastic bottles into combinations of other materials. This is an interesting approach which also could help to deal with the problem of waste. Different ideas abound but so far none is being implemented on a major scale. Apart from research, there is the question of transferability, even from one village to another. Naturally the local population must be convinced of the advantages of any new technology which departs from its traditions. Besides, in Africa, it is not a case of buying standardised bricks from a building supplies store. The producer adapts his mixture to the amount of money the customer has.

M. Hoppe: It is also important in each case to define where the bricks will be utilised – in the city or the rural areas? What materials and technology are on hand? How can the materials be processed and what are the available options?

E. Tetzner: Until now we have always succeeded in interesting policy-makers in our projects. They are often keen to get support for their substantial housing schemes. But not enough people are willing to implement these projects with us. Few medium-sized German

Top photo: The bricks made of local earth are not weatherproof. Often enough, a series of tropical rainfalls can cause the houses to collapse. Centre and bottom photos: The mud bricks were mostly made by hand – from cutting up the plant material with sheers or a maize mill to preparing the mixture. The final process was performed with a two-pivot block machine.

Photos: C.S.P. GmbH

companies are prepared to come to Africa. And at the local level we are confronted with the cement industry lobby which does not necessarily welcome such innovations.

Apart from building materials – in which other areas are you active?

G. Gäbler: It all depends on the requirements of our partners. In most cases we meet future partners at special events. When it appears that a specific raw material of a specific quality is needed, we are able to say, based on our experience, where this could come from. Some companies exclude certain countries or regions and we have to adapt our recommendations accordingly. This is often the case with Africa and particularly with Sudan; the financial embargo imposed by the USA keeps companies away, despite Sudan's immeasurable resource riches.

Are there certain resources which you consider especially promising?

G. Gäbler: Currently we see major potential in plant fibres such as hemp, linen, nettle, banana and pineapple, jute and sisal. The long fibres are almost always suitable for textiles – certainly for the manufacture of rope – and the short ones for fleece, as fillers or reinforcing fibres for injection moulding granules. From textiles to brake linings, the range of applications is enormous.

What about income opportunities for developing countries?

E. Tetzner: We are currently working on an itinerary for an African company which is interested in manufacturing banana fibre, a waste product of banana production, for textiles. With the University of Zittau, we have found a method of extracting the fibre using relatively simple technology. With this technology, even small farmers could produce fibre of a reliable quality, enabling them to directly supply

Photo: S. Richter

Plant fibres like those of bananas represent a promising raw material, also for smallholder production.

major companies which demand quality consistency. Besides, the production process generates a residue, a suspension, which can be used in small biogas facilities, which in turn could generate the power needed for drying or to drive motors. This cascade of processes delivers a whole range of high-grade resources. And the most promising thing with regard to smallholders is that they can indeed produce equivalent resources on the smallest plots of land, in a decentralised fashion.

This all sounds very promising. With corresponding national strategies, can we expect a boom in biomass use in the years to come?

G. Gäbler: We have a long way to go yet. We believe that many strategies are conceived at the negotiating table and disregard the stark realities. If manufacturing did convert to the bioeconomy, masses of raw materials would be needed, requiring thousands of hectares of arable land. This huge land requirement can't be met at all in Germany or in Europe; this aspect, however, is often not taken into account in the strategies.

E. Tetzner: In Europe we promote agriculture and other sectors entirely separately. There is little chance of involving farmers in publicly financed bioeconomy projects. But it is the farmers who have to conduct trials on their land, come to grips with the demands placed on the resource and see if the project can work. Further, the provisions of agricultural policy are so restrictive that they often stand in the way of projects. We know, for instance, the case of a biorefinery in Germany that has difficulty in securing supplies of grass, because grassland management is so strictly regulated within the EU. Overall funding policies need to become more balanced and more flexible if they are not to exclude entire regions and sectors.

G. Gäbler: It is also tricky that we have to deal with diverse sectors and types of industrial companies. The energy sector is relatively straightforward, as the individual tiers are clearly defined. But when it comes to the material use of plants, we have to deal with partners who have quite disparate competencies and responsibilities. It is virtually impossible to find overarching solutions involving several ministries. The result is that major industrial enterprises often leave such projects well alone. They work exclusively with their own resources or they opt out altogether.

Aside from these framework conditions – how does your work differ from dealing with "conventional" raw materials?

E. Tetzner: Contact with the farmers is extremely important: it can make or break a project. We must be able to rely on our local partners' making their raw materials available to us long-term – even if these are "only" waste. This calls for planning and co-operation from the start, since these projects can have a lead time of three to five years. At the same time we have a tremendous responsibility towards small-scale producers in particular. It is not enough to guarantee them a good price because this could encourage them to convert their entire production although they might be forced to buy food later on, when prices have perhaps skyrocketed. The farmers must be enabled to keep on producing their daily needs. Furthermore, we try to find solutions which enable them to work with the equipment and technologies that are available locally.

Silvia Richter conducted the interview.

Global Bioenergy Partnership: working together for sustainable developement

The Global Bioenergy Partnership (GBEP) is an international initiative established in 2006 to implement the commitments taken by the G8 in the 2005 Gleneagles Plan of Action to support „biomass and biofuels deployment, particularly in developing countries where biomass' use is prevalent". It received support from the G20 Ministers of Agriculture in the Paris Action Plan (June 2011) as well as from the G20 Leaders in the 2013 G20 Saint Petersburg Declaration. At present, GBEP brings together 37 Partners and 39 Observers from governments, international organisations as well as private and civil society stakeholders in a joint commitment to advance bioenergy for sustainable development, climate change mitigation and food and energy security.

The GBEP sustainability indicators for bioenergy

The production and use of bioenergy is growing in many parts of the world as countries seek to diversify their energy sources in a manner that helps promote sustainable development. Modern bioenergy can provide multiple benefits, including promoting rural economic development, increasing household income, mitigating climate change and providing access to modern energy services. On the other hand, bioenergy can also be associated with challenges including biodiversity loss, deforestation and additional pressure on water resources and land. GBEP has developed a set of 24 voluntary, science-based sustainability indicators with the aim to guide analysis of bioenergy at the domestic level and to inform decision-making facilitating the sustainable development of bioenergy. "The Global Bioenergy Partnership Sustainability Indicators for Bioenergy" report, published in December 2011, provides an invaluable resource in helping countries to assess and develop sustainable production and use of bioenergy.

In order to establish the feasibility of these indicators and enhance their practicality as a tool to support policy-making towards sustainable development of bioenergy, they are being tested in several countries. To mention a few examples, the UN Food and Agriculture Organization (FAO) is implementing the indicators in Colombia and Indonesia with the support of the Government of Germany. The project aims to assess and enhance the capacity of the two countries to measure the GBEP indicators and use them to inform bioenergy policy-making and other stakeholders in the countries towards a sustainable development of bioenergy. The project, which is coming to an end this September, also provides lessons about how to apply the indicators as a tool for sustainable development and how to enhance their practicality.

In 2012, a pilot study was developed by the Ghanaian Government with the support of the Dutch Government. The study provided very useful information about the country's data availability and quality in relation to the measurement of the indicators. In addition, many other countries have implemented, are implementing or have committed to implement the GBEP indicators.

Capacity building activities

GBEP is currently working on capacity building activities and projects for sustainable bioenergy, including through the implementation of its sustainability indicators and methodological framework on greenhouse gas (GHG) emissions. These activities aim at raising awareness of the potential benefits of sustainable modern bioenergy through multiple means, including workshops, study tours and other ways to present sustainable practices and assess resources. In this context, GBEP focused on the ECOWAS region and organised, inter alia, a Regional Bioenergy Forum in Bamako/Mali in 2012, to initiate a regional dialogue and peer-to-peer learning to support ECOWAS Member States in developing the ECOWAS Bioenergy Strategy, which was adopted by the ECOWAS Ministers of Energy in October 2012. In the past two years, the Partnership has also organised two Bioenergy Weeks, one in Brazil and one in Mozambique, consisting of training sessions on specific themes related to sustainable bioenergy, where effective policy frameworks were discussed, taking into account the GBEP work on sustainability indicators. These weeks allowed a fruitful discussion among public and private actors about the main opportunities and challenges of bioenergy production and use in both Latin America and Africa.

The way forward

A voluntary partnership of developed and developing countries and international organisations such as GBEP is an effective and innovative vehicle for co-ordinated progress towards low-carbon, sustainable development. The Partnership will continue to promote global high-level policy dialogue on bioenergy and facilitate international co-operation on modern bioenergy in a way to achieve the opportunities and face the challenges it brings.

Photo: GBEP

Participants of the first GBEP Bioenergy Week, held in Brasilia, Brazil in March 2013.

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Increasing resource efficiency by cascading use of biomass

Biomass is a natural resource with a number of competing uses: food, feed, materials and energy. The demands of a growing world population cannot be met without using this valuable resource in more efficient and more sustainable ways. There are now many experts arguing that biomass should be exploited in chronologically sequential steps of material uses. These steps should be taken as often and as efficiently as possible, with the final step, energy recovery, coming at the very end of a product life-cycle. The principle here is called „cascading use".

The totality of plant, animal and microbial biomass is based on photosynthetic primary production. Biomass can serve in its material applications as a raw material for producing goods of every kind and as a direct component of the products themselves. This contribution is what distinguishes the material uses from energy recovery – where biomass serves solely as an energy source – and also from food and feed uses. There are many theories and concepts about cascading use of biomass based on different conceptions of what "cascading" means. These concepts cover various aspects, from repairable and second-hand products, to complex combinations of main, by- and co-products in what are called primary and secondary cascades. We find here thematic overlaps with other approaches, such as circular economy and recycling. The term "cascading" can also have different meanings in different contexts. However, all the various concepts have one thing in common: at some stage at least one product has a material use.

Defining cascading use of biomass

The following definition of the cascading use at the product level is intended to clarify the essence of the existing theories and concepts:

- Cascading use of biomass takes place when biomass is processed into a bio-based final product and this final product is used at least once more, either for materials or energy.
- Cascading use of biomass is described as "single-stage" when the bio-based final product is directly used for energy.
- Cascading use of biomass is described as "multi-stage" when biomass is processed into a bio-based final product and this final product is used at least once more as a material. It is only after at least two uses as a material that energy recovery is permitted.

The figure on page 29 shows the material flows in single-stage and multi-stage cascading uses of biomass.

Single-stage cascading use already involves a significant increase in resource efficiency compared to direct use for energy recovery and can be applied to many existing bio-based value chains. Multi-stage cascading use results in bigger gains in resource efficiency. However, it has so far only been achieved from a very small number of biomass sources or has only been possible with a limited number of value chains.

In the Global South we already find widespread cascading use in the case of paper production. Starting as a raw material, wood is converted into cellulose, from which paper is manufactured. This paper can then be collected, processed as recycled paper and used sequentially as paper and cardboard. However, there are many other types of biomass with great – but as yet untapped – potential for material uses. This can be seen in the case of fibres of plant origin (jute, sisal, cotton, hemp and others) and bioplastics. Natural fibres can be used to make textiles, which can be recovered after use, reused once again as a textile, and later turned into insulating materials or composite materials. The same cascade can also be followed by cellulose fibres, with wood being utilised as a raw material for the production of textiles.

Bioplastics can be manufactured from plants containing starch and sugar such as maize and sugar cane. Here, a cascading use might begin with the production of bio-based polyethylene terephthalate (PET) for use in the production of beverage bottles. After repeated use, these bottles can be transformed into polyester-based textiles. Another example of cascading use in the field of bioplastics is the production of polylactic acid (PLA) from maize. PLA can be used in an initial use as a textile and, in later steps, repeatedly serve as packaging material.

Ecological assessment: the case of the wood cascade

A widely quoted example of how biomass use can be cascaded is the wood cascade. The use of solid wood in furniture, the subsequent use of this furniture as a raw material for particle board, the possible recycling of particle boards and the final incineration describes a cascading use that im-

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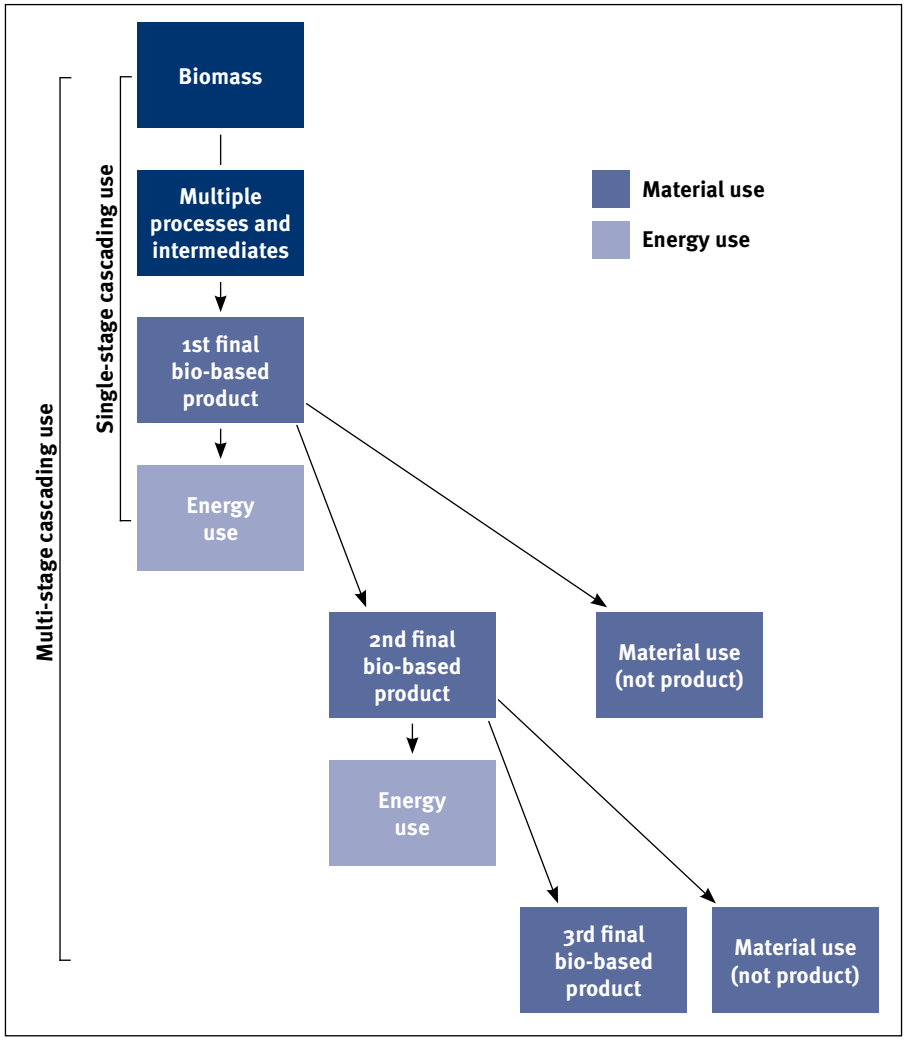
Distinction between single-stage and multi-stage cascading use of biomass



proves resource efficiency by reducing the input of wood as a raw material for the same output of products. In other words, the raw material wood is used sequentially in a series of different applications and finally turned into energy. In so doing, it passes through "use cascades" that flow from a high value-added level to lower levels. Moreover, the deployed biomass acts as a carbon sink in as much as there is a long delay in the release of harmful greenhouse gases into the atmosphere that occurs with the direct use for energy recovery. In most cases, we can say in principle that the more stages of – where possible high-value – material use are passed through by biomass before its final use for energy recovery, the less will be the environmental impact. So, from an ecological standpoint, material uses are preferable to a direct energy use.

Barriers to cascading use of biomass

To date only a few examples of biomass cascades have been realised in Europe. The reasons are varied. Although recycling is accorded priority over energy recovery in the waste hierarchy of the European Framework Directive on Waste, the reality is that it is rare for a biomass stream to find its way into repeated material uses. The policy environment and regulatory system in Europe favours direct use for energy recovery. Other barriers to a roll-out of cascading use can include insufficient volumes, poor quality or contamination of the biomass stream. And there are problems concerning commercial viability of the supply chain and reprocessing as well as diminished technical properties of products. Products made of "recycled and supposedly inferior" base materials often have a negative image, and this can also be a factor behind the lack of cascades.

Opportunities for cascade use in rural areas

In addition to meeting the demand for food and feed, biomass also performs many other functions for the daily needs of the population. Derived timber products, natural fibres, chemicals and medical drugs are just a few examples of the wealth of possibilities offered by the material utilisation of biomass. As the bioeconomy develops, research will look into a host of other potential biomass applications in innovative bio-based products. In this context, the strategy of cascading use of biomass can make a decisive contribution to raising resource efficiency. This also applies to the rural areas, which have favourable structures for exploiting the large biomass potential. It is not only a matter of the actual harvested biomass from cultivation but also of harvest by-products, meadow biomass and biogenic processing waste. Every form of material use can serve here as the starting point for cascading use, with all its potential benefits for the environment and for employment – even if the new cascades are not at first "multi-stage". The main point is: you can only incinerate once!

The cascades are currently being studied as part of the research project on "Increasing resource efficiency by cascading use of biomass – from theory to practice", which is funded by Germany's Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and overseen by the Federal Environment Agency (Umweltbundesamt).

For more information (in German): ➤ **www.biomassekaskaden.de**

Cassava – how to explore the "all-sufficient"

Making better and more diversified use of plants in order to benefit from existing resources is one of the targets that the bioeconomy has set itself. As a rule, however, this means that first of all, a lot of research has to be carried out, as the following example of Cassava shows.

Cassava is widely grown in nearly 105 tropical and subtropical countries with an estimated production of 263 million tonnes in 2012. The plant is considered as a 21st century crop as it responds to the global economy trends and climate change challenges. Cassava is a staple food for one billion people, but it is equally important as a source of feed and industrial applications, and is also an energy source, making it ideally suitable for cascade use (see article on pages 28–29).

After processing, cassava roots provide flour for human consumption. Bread, crackers, cakes and ice cream cones are produced from cassava flour. Cassava root starch is a high value commodity in brewing, textile, pharmaceutical, paper and oil industries. Cassava starch can also be a source for platform chemicals and ethanol production. Native starch is modified by physical, chemical or enzymatic processes to obtain different modified starch having numerous applications, e.g. preparing different types of foods, textile sizing, high-quality paper and animal feed. By using starch and modified starch, bio-/photo-degradable plastics can also be produced. Various sweeteners can be prepared from cassava starch by hydrolysis with acidic and enzymatic substances or a combination of both. Acetic acid, citric acid and itaconic acids prepared from cassava starch can be used in food industry and for producing synthetic resins, plastics and rubber products. Cassava leaves are used as food, feed and to raise silkworms, while mushrooms can be grown with the ground stems. Finally, the waste from the cassava field and processing industry can be used to produce biogas.

From waste to food: making use of the leaves

There is still a big potential to explore cascade uses of cassava. Post-harvest loss is a serious concern which needs to be addressed while introducing innovative processes. A huge amount of waste generated in the form of peel, pulp, wastewater and leaves during post-harvest processing of cassava causes severe environmental problems which need to be converted into valuable products and energy in an environmentally friendly manner. One of the plant's most valuable wastes is cassava leaves. They are rich in protein and nutrients and should be utilised properly in order to tackle food insecurity and undernutrition prevailing in developing countries. Therefore, we are going to focus more on the cassava leaves as an economical and sustainable source of protein and nutrients.

The global demand for protein is increasing tremendously. According to the UN Food and Agriculture Organization (FAO), world-wide meat consumption is estimated to reach 463 million tonnes by 2050, requiring a huge amount of feed protein which will be hard to produce in an eco-sustainable way. On the other hand, plant protein (mainly of legumes, grains, nuts and seeds) evidently contributes to meeting the demand for food protein worldwide. In order to cover increasing protein demand, it is necessary to explore new protein sources. Cassava leaves are one of these interesting sources. However, they are generally considered as waste or as an inferior by-product and are only used for human consumption in small quantities.

Cassava leaves contain high amounts of protein (17.7–38.1 % on dry weight basis). In addition they are a rich source

Cassava leaves could play a key role in food security. Research at Hohenheim University is examining the optimal way to treat the leaves.

Photo: T. Wojciechowski

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of vitamins, B1, B2 and C, as well as carotenoids and minerals. The total essential amino acid amount in cassava leaf protein is similar to that of a hen's egg and greater than that of spinach leaf, soybean, oat or rice. The Congolese call cassava 'all-sufficient' as they can get bread from the roots and 'meat' from the leaves. Cassava leaves are available throughout the year and should be given as much attention as the roots.

Identifying the right procession method

Cassava leaves are consumed in various cassava-growing countries when people don't have alternatives. Toxicity and antinutrients limit the consumption of cassava leaves as food. Cyanogenic glucosides (linamarin and lotaustralin) are responsible for the toxicity of cassava leaves, which is 5–20 times higher than that of the roots. Hence the consumption of cassava leaves may cause cyanide poisoning having symptoms like headache, dizziness, nausea, diarrhoea and vomiting, sometimes leading to death. These toxic and antinutritional aspects must be addressed properly during processing before consumption. Various cassava leaf processing methods have been developed. Drying, pounding and long periods of boiling are the traditional methods for preparing cassava leaves, while pounding cassava leaves in a wooden pestle and mortar for 15 minutes followed by boiling in water for 10–120 minutes is the most common method. According to the literature, even ten minutes of boiling may reduce 60 per cent of vitamin C content, and considerable losses may occur regarding vitamin A and the vitamin B group. Boiling may also denature the native enzymes (linamarase and hydroxy nitrile lyase), which are responsible for the breakdown of toxic compounds (linamarin and acetone cyanohydrin, respectively). Most of the processing methods are not able to completely detoxify the cassava leaves to the safe consumption level; there is still a need to develop efficient, simple, and low-cost processing methods to deal with not only toxic but also antinutritional aspects, low digestibility and bad taste while retaining all the key nutrients.

Cassava leaf protein utilisation is also limited by the presence of high levels of chlorophyll, xanthophylls and fibre, which can be overcome by extracting juice from the leaves, followed by coagulation to get leaf protein concentrate (LPC). Chopped, ground cassava leaves are pressed and coagulated with steam injection. Several studies have been carried out on the preparation of LPC, but a wide variation has been observed in terms of extraction efficiency, nutritional value, methionine and lysine, which may be due to the extraction methods and tannin contents in different cassava varieties and cultivars. Ultimately, the attempts to prepare LPC on an industrial scale failed because of low protein recovery with high contents of tannins and the low digestibility of the residue fibre. Further work is needed to develop novel technologies with high protein recovery and valuable by-products. In another approach, cassava leaf meal (CLM) or cassava pellets can be prepared by pressing cake or whole leaves and stems by reducing the moisture content (15–20 %) either with sun drying or mechanical pressing.

Food insecurity prevails not only among the 842 million people of the world who are hungry but also among the three billion people who can cover their minimum dietary energy requirement but suffer from various diseases caused by undernutrition (or malnutrition). After the successful development of suitable processing methods, cassava leaves have the potential to provide an enormous protein and nutritional source to the vast majority of the population and hence can increase food and nutritional security.

Photos: S. Latif and J. Freihart

Two ways to unlock the nutrients of cassava leaves: Cassava leaf juice and press cake.

Cassava protein for nutritious diets

Based on consumer preferences, nutritionally balanced foods (snacks) or modified traditional foods can be prepared with cassava leaves to provide the required amount of protein, minerals and vitamins. Similar efforts have already been made in Brazil to combat malnutrition especially for pregnant women and children. A food supplement called 'multimistura' has been prepared by using cassava leaf powder as one of the ingredients. A typical cassava leaf dish including fish, capsicums, groundnuts and onions is prepared in Sierra Leone. Such food products need to be promoted in order to encourage cassava leaf consumption as a valuable component of the diet instead of associating them with poverty. Fortification of common food items with protein and nutrient-rich cassava leaves can be a sustainable and cost-effective approach to dealing with protein and micronutrients deficiencies in millions of people.

Is Africa "ready" for an integrated bioeconomy approach?

With its abundance of natural resources, Africa appears to be predestined for a type of economy that centres on the use of bio-based resources. However, before a comprehensive approach can be applied, a large number of framework conditions and policies will have to change, Adebayo Abass maintains.

There is an acute shortage of food, feed and energy in Africa despite the availability of vast arable land and agro-climatic conditions conducive to competitive biomass production. Bioeconomy development (as part of the green economy) is a useful approach to advancing sustainable growth of African economies, reducing expenditure on oil imports by improving energy supplies, diversifying the markets for agricultural commodities and increasing rural incomes.

However, there are a number of difficult challenges associated with the development of an integrated bioeconomy. These include infrastructure, resource allocation, imaginary or real 'land grab', food insecurity, research capacity, access to technology, lack of any clear policy objectives and sector management problems. Nonetheless, the African scientific community agrees on the need to develop Africa's scientific capacity to ensure Africa participates and benefits from the growing global bioeconomy. Biomass-based concepts must be adapted to Africa by adopting a new higher order approach to improving the efficiency of biomass supply-demand systems. In pursuit of this objective, Africa needs to take the following actions:

Improve land allocation arrangements: The existence of sufficient arable land and the inflow of foreign investment in large-scale agriculture offer opportunities for producing the biomass that Africa needs for food output and moving towards a bioeconomy. But land tenure issues and the reality or fear of 'land grabbing' for growing biomass for biofuels threaten progress in this direction. Biofuel production is expanding across Africa amidst concerns that it does not serve Africa's own energy needs and perceptions that large-scale biofuel crop plantations can lead to land dispossession, deforestation and lower carbon savings. This would result in negative impacts and not benefit rural communities and the environment. It is estimated that 50 or so biofuel-producing foreign companies already hold over five million hectares of land, with plantations in more than 25 African countries. Spreading ownership and use of large farms for biofuel crops is perceived as competing for food-growing and animal-grazing land, potentially reducing access to food and pushing up local food prices. Innovative approaches to land allocation are now required to spur large-scale production of biomass and processing for both food and bioproducts for use in Africa.

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Resolve the food security scare: Africa currently grows a number of crops and plant oils that are candidates for bioethanol or biodiesel production – such as cassava, sorghum, maize, sugarcane, palm oil, castor, jatropha curcas and sunflower. Yet most of these crops are also important for food security. The unabated high post-harvest food losses in Africa aggravate food insecurity and further heighten the scare to divert the available meagre foods to non-food uses (see Abass et al. 2014). Consequently, many African governments face a policy dilemma: whether to keep on using crops for food security or promote their cultivation for renewable energy applications. The thinking is generally that producing renewable bioproducts from food security crops (e.g. maize, sorghum and cassava) will impact negatively on the food security and nutrition of resource-poor populations. On the other hand, some African governments argue that increased agriculture commercialisation, along with industrial-scale processing of crops into bioproducts will create new market opportunities for Africans. The demand-pull would then spur the adoption of improved agricultural technologies that can boost productivity and strengthen food security. In view of food security concerns, there appears to be no consensus on the use of food crops to develop Africa's bioeconomy and certainly no concerted action. The majority of African countries have yet to develop any form of integrated bioeconomy development strategy. Countries such as Nigeria, Ghana, Namibia, Uganda, Ethiopia, South Africa, Kenya, Mozambique, Democratic Republic of Congo, Mali, Congo, Tanzania and Zimbabwe do have some bioeconomy development activities based on various crops and oil plants, but there is no evidence of any significant positive impact on the economy.

Improve research and development skills: Integrated bioeconomy development requires significant research exper-

Simple storage technologies to prevent post-harvest losses.

Photos: A. Abass

Processing high-quality cassava flour for use in bakery products.

tise and human capital to harness productivity and make efficiency gains from biomass production. It entails innovative processing, cascading industrial utilisation and efficient trading and marketing systems. These areas have become a focus of African research endeavours. African scientists have generated scientific knowledge in the cultivation and transformation of specific crops, such as cassava, to produce bioproducts. In collaboration with advanced research centres in Europe and America, African scientists are currently experimenting with a new approach known as the „value web" (see article on pages 16–18), which is designed to increase biomass utilisation by introducing a stream of technologies and building scientific capacity as opposed to „value chain" that has less scope. To this end, partnerships are being developed with Brazil, India and the European Union to acquire biofuel technologies. Advances in scientific research capacity and technology transfer in this field are expected to enhance Africa's ability to engage in integrated bioeconomy development.

Analyse fossil fuel dependency trends: Many African countries are net fossil fuel importers. Expenditure on oil can amount to 20 or even 40 per cent of total import expenditures. On the other hand, some countries have developed a petroleum refining infrastructure, while a few others have recently discovered vast reserves of petroleum. Since Africa is not yet a major contributor to greenhouse gas emissions, there is less pressure to mitigate carbon emissions. So dependency on the use of fossil fuels is likely to continue. For the oil-producing countries, the fossil fuel extraction costs are lower than those of biofuel production. The technologies for oil refining are readily available, and the distribution logistics are easier than with biomass-based energy products such as biodiesel, biogas, biofuels or ethanol. Dependency on fossil fuels by oil-producing African countries is likely to increase.

Improve policies, strengthen markets and build management capacity: The development of science and technology for biomass production and processing needs to be supported with the right policies. Under the African Union's sustainable energy strategy for the continent, it encourages member states to endorse policies, guidelines and regulatory frameworks that promote biofuels. Some African countries (including Nigeria, South Africa, Tanzania and Malawi) already have policies and legislative guidelines for using biofuels in motor vehicles, although most policies lack the necessary integration in legislation. In order to work, they need to be flanked by other policies, mechanisms and infrastructures (such as refineries) to ensure that the bioproducts processed from the crops are channelled into meeting national energy needs.

To conclude: As an emerging, multi-sectoral phenomenon, the bioeconomy will require multifaceted and interconnected management approaches to competitive biomass production and transformation – judiciously used for food, feed and renewable energy as part of sustainable and balanced economic growth of Africa. A great deal remains to be done. For an integrated bioeconomy development demands adequate financing, clear objectives and strong leadership to create the necessary policy environment. Multiple expertise and technologies are needed to produce renewable energy and bioproducts while simultaneously achieving food security, creating jobs, generating revenues and reducing both fossil fuel dependency and greenhouse gas emissions.

A combination of local and foreign investment must be harnessed to reduce fuel imports and increase bioproduct exports. Moreover, greater investment in research is needed, with a stronger focus on creating a comprehensive and integrated renewable energy system in Africa. If bioeconomy development is to be broad-based, sustainable and equitable – avoiding adverse impacts on ecosystems and food security – African policy makers will have to articulate how their bioeconomy programmes can be implemented in ways that advance the economies of rural communities.

References: ➤ **www.rural21.com**

Bioeconomy – A dead end

The bioeconomy above all focuses on technological innovation to make better use of available resources. In principle, this is not a bad idea, says Barbara Unmüßig. The question though is for the benefit of whom and at whose expense these innovations are implemented, and also what the undesirable side-effects are like. A plea against focusing on growth.

Prior to the Rio+20 summit a variety of international actors including the United Nations Environment Programme (UNEP), the OECD and the World Bank launched the concept of the green economy – envisaged as a retreat from our fossil-fuelled, resource-intensive global economy. They hoped that the green economy would be enshrined as a core concept in the Rio+20 closing statement, "The Future We Want". This did not eventuate. The European Union would have liked to see the summit adopt a roadmap for a green economy. This, too, did not emerge.

The starting point of all reflections on a green economy is climate change and the scarcity of resources – think "peak oil", "peak water" and "peak soil". For this reason all its protagonists want to see ecological transformation towards a decarbonisation of the global economy – with massive investment in resource efficiency and renewable energies. "Business as usual" should no longer be an option. This assertion crops up repeatedly in the numerous publications and studies on the topic.

But the green economy comes with a catch – more than one in fact. Its protagonists do not challenge the imperative to generate economic growth. For instance, in May 2012 the OECD put forward a strategy entitled "Towards Green Growth". Growth remains at the heart of economic theory and policy. We search the green economy concepts in vain for any stimulus aimed at a post-growth economy or prosperity without growth – particularly for the industrialised nations. It has no place for the idea and the necessity for "less" in the affluent North. And conversely, any concept or strategy for a growth economy which is sparing in its use of resources and alleviates poverty continues to receive little exposure. There is scant reference to crucial social and human-rights dimensions such as the right to food, access to water, education and land. The green economy is reduced to purely economic parameters such as efficiency and productivity, with little emphasis on rights, standards and issues of distribution and power. This also holds true for the Inclusive Green Growth model presented by the World Bank.

Photo: B. Keller

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Furthermore, technological innovation takes pride of place in the concepts of green economy. The underlying approach, correct in itself, is that technological solutions raise the productivity of resources consumed and can allow the substitution of scarce resources. It is still vital, however, to look closely at the potentially negative social and ecological effects, particularly where industrial-scale solutions are involved. Not everything thought to be a response to climate change – ocean fertilisation, massive mirrors in space, nuclear power, large dams – is socially equitable and ecologically sound. The same applies to genetic engineering which is supposed to help solve the food crisis. Anything bearing the label of the green economy must surely put the social, human rights and ecological perspectives on an equal footing with the economic goals. For instance, if wind farms expel populations from their land, then despite contributing to a more positive carbon balance, they can exacerbate poverty and local conflict. Wind turbines also contain large amounts of resources, the extraction of which often fails to comply with social standards and human rights principles. Too much political energy is spent on securing supplies rather than promoting the saving and recycling of resources; at the same time, political and economic incentives for resource efficiency and conservation are virtually non-existent.

There is no doubt that we need to transform our modes of production and consumption. This can occur not only – albeit mainly – through the economy. At best the green economy is now an isolated niche activity. By contrast, the major trend is the global and hugely-growing demand for fossil, mineral and biotic resources. The reasons for this are manifold. On one side the industrialised nations have freely exploited all kinds of resources for centuries, and they are not prepared to budge from their accustomed level of fossil and resource-intensive production and consumption. On the other side, in the wake of economic globalisation new "competitors", producers and consumers have arrived on the scene. Their development model, too, is largely based on fossil energy and a production and consumption model which emulates that enjoyed in the industrialised countries. It's business as usual, but on a global scale!

What this means in terms of crossing planetary boundaries can be illustrated by taking the agricultural sector as an

example. It is responsible for the loss of biodiversity, over-fertilisation of the oceans, large-scale land-use changes and the destruction of nitrogen cycles. If, for example, the global demand for meat continues to develop as it has in recent years, the OECD expects that by 2050 animal feed supplies will need to increase by almost 300 million tonnes. How and where this amount of additional feed should be produced is not at all clear, because one third of the 14 billion hectares under cultivation worldwide is already devoted to growing feedstuffs, and China imports three quarters of the soy produced for the global market. The EU is the second-largest importer after China. Moreover, both Europe and the USA in particular are now devoting an increasing proportion of their agricultural production to biofuels. The USA today utilises about 30 per cent of its maize crop to produce ethanol. By 2020, if the EU adheres to its current objectives (biofuel blending quota of 10 %), approximately 85 per cent of the politically-driven demand for biofuels in Europe would be directly or indirectly covered by imports. This would correspond to 1.8 times the output of the total 11.8 million hectares of cultivated land area in Germany.

This is where the bioeconomy comes into play. It conceives of itself as a form of green economy. It is also an expression of fixation on technological solutions as a panacea to all our problems. In 2013 the German Federal Government published its National Policy Strategy on Bioeconomy. This document describes bioeconomy as an opportunity to address the challenges facing us, such as resource scarcity, climate change, soil loss and food security; and "simultaneously to advance the transition from an economy mainly using fossil-based raw materials to an economy based on renewable resources and efficient in terms of raw materials." It's true: our world depends on oil, which can be found in nearly everything. Bio-plastics are seen as one way to escape the "oil trap". They are produced from plant-based resources and residues from food and wood production. However, there is a deafening silence about the actual constraints which exist on the substitution of oil with biological resources. Renewable does not mean infinite, and certainly not absolutely neutral in terms of environmental effects. Land is already scarce, over-utilised or degraded. Land-use conflict will increase. One of the major weaknesses of the bioeconomy concept is that the entire development of product supply by the agricultural sector is disregarded and global challenges such as poverty and hunger alleviation, as well as adherence to planetary boundaries are ignored.

Offsetting "peak oil" with renewable resources creates a vicious circle. Not to mention "peak soil"; soil will become increasingly scarce. If food cultivation takes second place to crops which are economically preferable, food security will continue to become food insecurity. This contradiction can also be extended to "peak water", because growing plants is water-intensive. Those in favour of bioeconomy also put their faith in strong production growth using genetic engineering and biotechnology. A full impact assessment which takes the various implications and reciprocal effects into account is not foreseeable. "Green" genetic engineering is a case in point: reports of new problems experienced with genetically-engineered plants are on the rise, not its success stories.

Further, it is anything but forward-looking and "inclusive" that multinationals such as Monsanto, Procter & Gamble, Chevron, BASF, Big Energy, B.I.G. Pharma, Big Food and Big Chemical are increasingly taking over strategic control of entire supply chains – from genetic and technological information on production methods, to factors such as energy, biomass, seed, water and land. The concentration of power looming here is alarming – the seed, fertiliser and pesticide lobby is exerting ever more influence on political decisions all over the world. Small-scale farmers and rural workers rarely have the power to defend themselves against the conditions set by the global corporations. Strong farmers' organisations acting in the interests of small farmers scarcely exist, as do unions to represent the rights of rural workers. Political action is urgently needed here to counter this trend.

Technological innovations and efficiency will continue to lead us towards a more resource-efficient economy and help to expand the ecological boundaries. All concepts of a green economy or the new bioeconomy must, however, first ask these questions: Technology and innovation yes – but for whom? Who will be in control? What will the social and ecological consequences be? Will they suffice or are they only tactics to avoid or put off the long-overdue trend reversal to a "policy of less"? It is for good reason that these issues are being ever more fiercely debated by governments, business and civil society. Only one thing is certain. Faced with such crises, we need a social and ecological transformation of our production and consumption model, towards a global economy that is democratic and fair and is not based on unfettered growth.

One of the major weaknesses of the bioeconomy concept is that the finiteness of resources is not sufficiently taken into account.

Photo: FAO / P. Johnson

Co-operation with the private sector

"Driver of development for smallholder farms"

To alleviate poverty and hunger in rural areas is a core political objective of the German Federal Ministry for Economic Cooperation and Development (BMZ). A key element of this task is the promotion of the farming and food sector. Because of its crucial importance to food security, our focus is on market-oriented familiy farms.

Unfavourable economic and political conditions are the cause of the continued prevalence of subsistence farming, with many small farmers remaining trapped in poverty and hunger. The resultant inability of families to invest in health, education, farm improvements and the sustainable use of their resources puts their entire socio-economic development at risk.

Agricultural entrepreneurship develops small family farms

Because each farmer is an independent operator (agripreneur), a critical step towards improving the family's situation is to increase profitability. The main focus is on enhancing productivity and efficiency, and at the same time marketing products in a more lucrative manner. The small-scale farmer can decide for himself whether to sell his harvest through a middleman, on the market or under contract to a processing company. Development co-operation should empower the farmer to choose the right development model for himself or herself, without being coerced into retaining the status quo. Farmers must be able to take their own business decisions and make use of sustainable production systems which are suited to their local conditions. This enables them to secure not only their own food supply but also to contribute to regional food security.

In many developing countries the changing tastes of a growing middle class for processed, high-quality, safe foods can only be satisfied by imports. On the one hand there are few local processing options, and on the other high-quality food is not produced at the right time and in sufficient quantities – not to mention the lack of transport infrastructure and storage. It is imperative that this enormous potential for local and regional production and processing is tapped. But, apart from all the shortcomings in terms of expertise, market access and market data, the main stumbling block in many cases is inadequate funding. To this day, the formal financial system can satisfy only a fraction of the need that exists. For this reason many worthwhile and self-amortising investments are not being made.

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Public and private investment is needed

What is needed is robust, broad-based agricultural finance which includes both public funding – for infrastructure, structural and regional policy for rural areas, agricultural policy, training and up-skilling programmes for farmers, investment incentive programmes, etc. – and private investment – from smallholder agriculture to major farming enterprises to co-operation with the national and international economy. Germany's agriculture and food industry is a strong partner which stands for values far beyond purely commercial benefit, such as reliability, expertise, quality products, long-term partnerships and sustainability. For this reason the BMZ considers initiatives such as the German Food Partnership (GFP) a valuable addition to purely official development policy.

Taking account of the market potential and absorptive capacity on the ground, we would like – with the assistance of these partnerships – to provide farming families with new opportunities to improve their product marketing in the context of a value chain approach, and to gain better access to expertise, funding and reliable purchasers by means of fixed contracts. Experience gathered thus far is to be utilised and transferred: German development co-operation has successfully helped increase the incomes of several hundred thousand small farmers in Africa, primarily in cash crop projects such as cotton, cocoa and cashew nuts. We want to expand this success to staple foods. An initial major project is the Competitive African Rice Initiative (CARI) under the auspices of the German Food Partnership, which aims to increase the incomes of up to 120,000 poor rice farmers in Africa.

A concerted approach that involves the entire rural community is needed for the mammoth "One World – No Hunger" task we have set ourselves. Provided the primary focus of all activities remains firmly and consistently on the needs of local farmers and future generations, much of the alleged controversy will not be controversial at all.

a viable approach?

"Perilous partnerships"

Whatever is the German Federal Ministry for Economic Cooperation and Development (BMZ) thinking of, involving agribusinesses such as Bayer and BASF in the fight against hunger? This is the question posed by 146 celebrities in an open letter to Chancellor Angela Merkel and Development Minister Gerd Müller in June. Further, a survey showed that Germany's population in general has a low opinion of agricultural corporations when it comes to fighting hunger. Their indignation and scepticism are more than justified. The direction that Germany is taking with this new generation of public-private partnerships such as the German Food Partnership (GFP) and the G8 New Alliance for Food Security and Nutrition is not only wrong, but risky. It is time to stop for a moment and look closely at such private sector co-operation to which governments are ascribing an increasingly key function in the alleviation of poverty and hunger. The more so because the GFP and the New Alliance are not isolated cases. Agricultural corporations are also engaged in the formation of Green Innovation Centres which are to become a vital component of Development Minister Müller's special initiative "One World – No Hunger".

Lack of transparency

The GFP projects launched so far reveal a basic problem here. They are always developed in close collaboration with agribusiness and private foundations, but without the participation of small-scale farmers or their organisations. The latter, however, are those who should be most involved in decision-making on the measures needed to improve their incomes and living conditions. The human rights perspective demands that marginalised groups should be supported as a priority. The GFP is also leading by poor example in terms of transparency – likewise a human rights principle. Very little information has been made available to the public. The project contracts agreed with corporations have thus far been kept confidential. Details of who is funding what and to what extent have not been disclosed.

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The GFP has set itself the task of increasing productivity and improving the efficiency of the production chain. A focus of the projects is to provide training for farmers. The BMZ grants Bayer, BASF and other companies far-reaching opportunities to use the courses as promotional events for themselves, and to influence the concept of the training courses to their own benefit. With respect to the Better Rice Initiative in Indonesia for instance, GFP companies are directly involved in developing training curricula and materials, as well as training and up-skilling programmes, and they are also funding agricultural advisers. A project manager engaged by BASF for the GFP project heads a large team of field coordinators. The GFP businesses are not only to contribute their "expertise" with their employees, however, but also with their products which are used in field trials and demonstrations.

Support for a non-sustainable production model

The corporations do not do this out of the goodness of their hearts, of course. At a GFP event in November 2013 Bayer CropScience stated unequivocally: "Our business happens to be the sale of crop protection agents and seeds." This has nothing to do with an independent advisory service. When it comes to training farmers in Germany, different standards apply altogether. Such close ties between agribusiness and development policy not only promise increasing profits to Bayer, BASF and the others, but also promote their concept of high-input, capital-intensive agriculture. The negative impact of such an agro-industrial and non-sustainable model, both on the environment and low-income small farmers, is not being adequately taken into account. Increasingly, traditional cultivation methods and seed varieties are being pushed to the fringes, and small-scale producers are in danger of becoming dependent on multinational corporations and their inputs, such as industrial seed and pesticides. It is not to be expected that the GFP projects will actively support agro-ecological practices aimed at paring down pesticide use.

The BMZ should put neither its political weight nor the development funds it administers behind questionable partnerships with major corporations which do not benefit the poorest of the poor, but in fact disadvantage them. There are far more effective, practicable public investment approaches such as the promotion of agro-ecology, women and local marketing which are more accessible to the rural poor and also protect the environment. To entrust corporations with a major role in the fight against hunger is a recipe for failure.

Mr Issoufou and the fight against hunger

Extended dry periods and drought are regular occurrences in Niger. Whenever rain falls short, people fear for their survival. But they do not give up. They laboriously wrest a harvest from the barren ground, determined to be prepared for the next crisis.

It's purely coincidental of course, that both men have exactly the same name. Issoufou Mahamadou is the chief of the small village of Soumaguela somewhere in the south of the vast desert country of Niger. The head of state, the President of the Republic of Niger, is also called Issoufou Mahamadou. This is not at all unusual, because Issoufou in the Hausa language means Yussuf or Joseph, and Mahamadou is a version of Mohammed – a common name in a predominantly Muslim nation. But despite their unremarkable-sounding names, their mission is far from unremarkable. Both men are fighting the hunger which afflicts their homeland and its people so regularly and relentlessly.

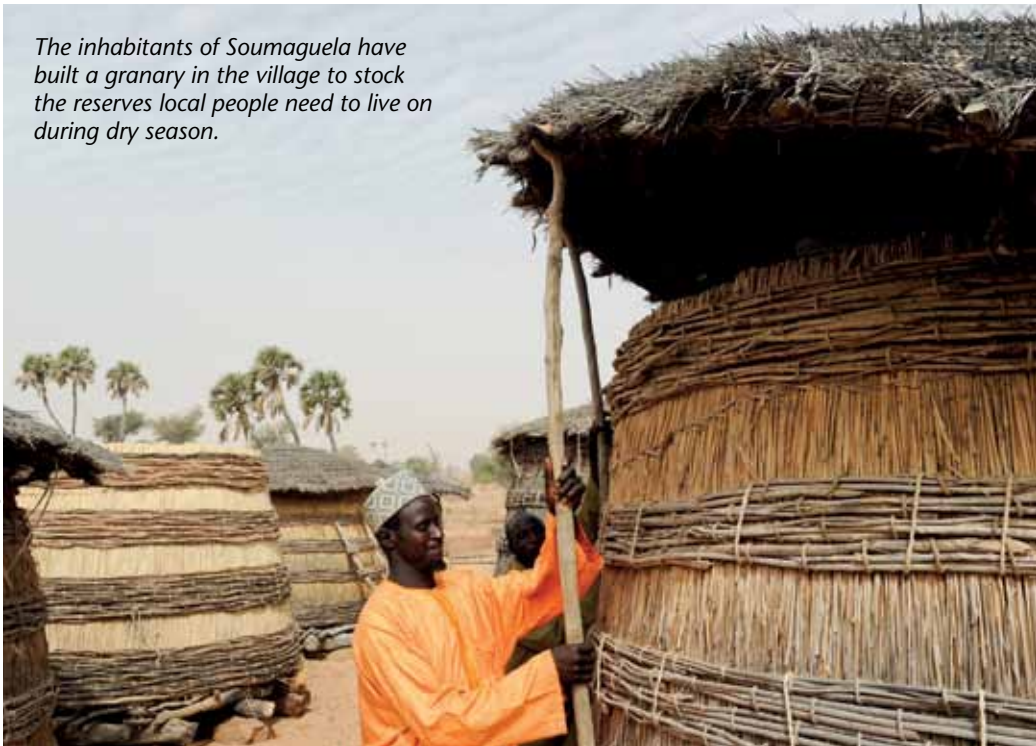
According to the Global Hunger Index, the situation in Niger is still "alarming". Every poor rainy season can trigger a major new crisis – such as the widespread famine which raged throughout the Sahel zone in 1973, and then again in 1984, 2000 and 2005. Even today in Niger, according to the United Nations, four out of every ten children under five years of age are still chronically undernourished. But there are people who want to change this state of affairs – including both men named Issoufou. Many observers see President Issoufou as a beacon of hope. This is because, as the latest hunger crisis loomed in September 2011, he did something unheard-of. He stepped up before the General Assembly of the United Nations in New York and said: "Esteemed ladies and gentlemen, we need your help." A humble act which his predecessors would have considered a sign of weakness. Prior presidents preferred to block foreign aid and play down the problems of their country – until it was almost too late: until drought and need had firmly taken hold of the nation and huge numbers of people were starving to death. This early warning in 2011 meant that the worst effects could be avoided.

The 3N Initiative

But President Issoufou has other objectives, too. He plans to ensure that famines become a thing of the past here, and to make Niger capable of feeding itself as far as possible. Upon taking up office he said: "It is a disgrace that we have to keep on begging other people to give us our daily bread." For this reason he has drawn up an ambitious programme: the 3N Initiative, which aims to reform agriculture and stock farming on a grand scale within the next five years. "3N" stands for "Les Nigériens nourissent le Niger" which means "Nigerians nourishing Nigerians". The fifteen A4-page document outlines the President's programme which includes greater mechanisation of agriculture and increases the number of areas under irrigation. Under the plan the population will also learn new methods of cultivation.

The planned volume of investment of 900 billion CFA Francs (1.37 billion euros) is expected to derive mainly from the income from mineral resources.

Niger is rich in natural resources – it is one of the world's largest uranium producers, for instance. In addition, a Chinese consortium has been extracting oil for a little over a year now.



The inhabitants of Soumaguela have built a granary in the village to stock the reserves local people need to live on during dry season.

Photo: J. Boethling

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Photo: J. Boethling

Issoufou Mahamadou it head of about 180 households in the small village of Soumaguela.

The President describes his approach as: "village by village, community by community."

How long will it take for the 3N Plan to reach Issoufou Mahamadou's village? As the local chief, he is the head of about 180 households, consisting of just under 1,000 people. His grandfather also held this office, which is passed down from father to son. Until now the main sentiment Issoufou has felt towards his government has been disappointment. "I have never been to Niamey", he says. The capital is more than ten hours' drive away. Issoufou Mahamdou rides a small "Royal" brand motor cycle, which takes him along dusty sand tracks to a water hole.

The dry season lasts more than eight months a year

It is late January, and the rainy season has just ended. The people have dammed up the water here, but it won't take long before it's all gone again. "We have about ten hectares of land available" says Issoufou, "but we can only cultivate ten per cent of it. We don't have enough water for the rest." The past weeks and months have been spent digging out a retention pond so that the water lasts just a little longer. Teams with donkeys and oxen come here from far and wide, laden with plastic containers.

The water hole provides drinking water for both people and animals, and it is essential for agriculture. "We only have four months", explains Issoufou. "During that time we have to plant and harvest our crops, to see us through the other eight months of the year." Green lettuces are growing next to the pool. "We sell them at the market," he says. The women do that, don't they? "No, salad is men's work. Our women sell tomatoes and onions." The main crop here – even more important than vegetables – is millet. They have built a granary in the village to store the reserves the local people need to live on during the dry season. "We have also dug several wells," says Issoufou. These have been fitted with motorised water pumps.

It is not the President who has organised all these programmes, but CADEV, the local development aid agency of the Catholic Church in Niger. Although Christians make up a small minority of the population, the social work they do is highly valued, which makes them influential. "The important thing is to include the local people in all the projects" says Raymond Younoussi Yoro, General Secretary of CADEV. Otherwise wells would be dug at locations where the land is not traditionally cultivated. "When this happens the people give the water to their animals, leaving nothing for themselves again," says Yoro. He can think of other challenges which continually slow them down in their race against famine.

According to Yoro, the past year was actually not so bad in terms of climate and rainfall. "But the crisis in our neighbouring country, Mali, has driven many refugees across the border to Niger, and now we have to provide for them as well." As a result food has once again become scarce. According to CADEV Secretary Yoro: "Hunger means that more than 3.6 million people in Niger now face a daily struggle to survive."

He goes on to say that food speculation is very difficult to control. Large numbers of businesspeople buy the harvests of cash-strapped farmers, and then store the crops on the border between Niger and Nigeria. "They wait until prices rise before selling, and thus profit from the food shortages," he says. He is quite restrained when asked his opinion on the commitment of the state. "A lot of money comes from the World Bank, too. But we'll have to wait and see how much of it actually reaches the people."

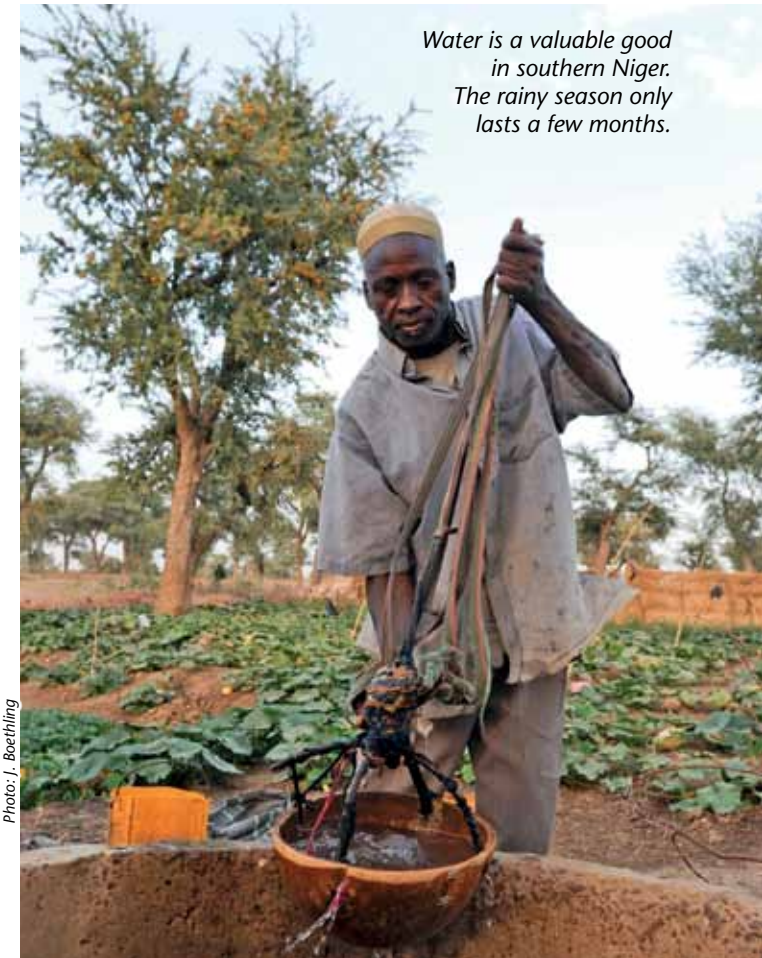

Photo: J. Boethling

Water is a valuable good in southern Niger. The rainy season only lasts a few months.

International Platform

Photo: J. Boethling

Infants are measured and weighed at the hospital in Zinder. The food allowance can be quickly adjusted when there are signs of malnutrition.

Hunger lurks around every corner

Raymond Younoussi Yoro is a devout Muslim. He doesn't consider working on behalf of the Catholic Church as a contradiction. In his village the people say: "Before the Christians arrived we used to have four sacks of millet in our store: now we have 250 sacks." Nonetheless hunger lurks around every corner, even in Mr Issoufou's village. Another kind of disaster – this time a flood of all things – has left even deeper scars. The population was desperate for the rain to come – but when it finally did, it lashed down so violently that the dry earth could no longer absorb it. It washed away mud walls and destroyed painstakingly-established livelihoods. "Now I am forced to choose" says a woman in the village. "Shall I repair my house, or shall I feed my children?" She is a widow who takes care of a large number of children, not all of them her own. "We eat once a day," she says, pointing to a pot in which she is stirring a thin porridge of millet. She could not survive without outside help. The United Nations World Food Programme (WFP) provides food to Niger on a regular basis, not only in times of crisis. Partner organisations distribute it, as does the Catholic Church.

Visit to a clinic in Zinder. This city of more than 300,000 inhabitants is the second largest in the country. Mr Issoufou's village is only eight kilometres from here. The clinic offers free treatment to patients suffering from tuberculosis, and the church runs a primary school next door. Once a day a warm meal is available, especially for young mothers and their children. The demand is great. The women queue up patiently to fill their bowls with millet porridge or rice.

The tense security situation adds to the difficulties

Small children are weighed and measured here. If the workers see any sign of undernourishment they can take immediate action and adjust the food allowance. At the centre of the throng is Sister Dolores Astorga, a Spanish nun. It is quite exceptional to come across a person with white skin here. For some time now the risk of being kidnapped by Islamist groups intent on destabilising Niger has been too great. Europeans are being strongly advised against travelling to the country, and even long-term diplomats rarely leave the confines of the capital, Niamey. Dolores Astorga has been living in Niger since 1968. "So far all has been well", she says. The precarious security situation adds yet another layer of difficulty to the fight against hunger. Where foreign aid workers have to fear for their lives, help often reaches the people too late. In such cases a crisis can quickly become a disaster.

Dolores Astorga picks up her notepad and records how much food they have distributed today on behalf of the United Nations. The WFP requires them to be absolutely exact with their bookkeeping. They allow 200 grams of millet, 30 grams of oil and 10 grams of sugar per person, per day – a total of 1,130 calories. Just enough to survive. "That's how it is here," says Dolores Astorga. "We take it step by step – one step forward and then sometimes another step back."

Soon the dry months will be upon the country. Then President Issoufou must show that he really is serious about his plan. Village head Issoufou must hope that his people will get through it somehow. Perhaps the men will find work on a construction site in the city. Perhaps relatives will send money from Nigeria or Côte d'Ivoire. Perhaps the stores will last this time. The people have stored grain and sold vegetables. They have dug wells and collected rainwater. They have cultivated the ground and produced the best harvest they could. They really couldn't have done more.

Niger in profile

The Republic of Niger in West Africa ranks last among 186 countries on the Human Development Index (HDI) of the United Nations. Its difficult climatic conditions are a particular challenge for the country and its 17 million inhabitants; extended periods of drought and famine are a regular occurrence. The security situation is also extremely tense. In 2010 President Tandja Mamadou who ruled the nation from 1999 was ousted in a military coup. The army promised to return the country rapidly to civilian rule, and this occurred following the elections of 2011, which were won by Issoufou Mahamadou. During the 1980s and 1990s Issoufou worked for the French nuclear group, AREVA, which mines uranium in Niger. China has also become an important partner. State-controlled Chinese oil company CNPC holds 60 per cent of shares in the new oil refinery at N'guigmi, close to the Chad border. The population is 95 per cent Muslim. Most of the three to five per cent Christians arrived as immigrants from neighbouring countries. The Catholic Church of Niger comprises the two dioceses of Niamey and Maradi. It advocates dialogue with Muslims, stands up for disadvantaged women in particular, and operates a number of schools and clinics. Through its development organisation CADEV (Caritas-Développement), the church is actively involved in the fight against hunger.

Improving healthcare through ICT for India's rural women: e-ASHA in Rajasthan

Despite the efforts of the Indian government, the majority of the most marginalised people residing in rural areas are still unable to access health services. A new ICT tool was tested with a target group of 40,000 individuals last year. The results are encouraging.

In India, the Accredited Social Health Activists (ASHAs) have long played an indispensable role in healthcare for the rural poor, above all in mother-child healthcare. They act as the first link between the health system and the rural community. ASHAs are local women who have been identified, selected and trained to act as health promoters in their communities. They generate health awareness and mobilise communities to engage in local health planning and greater use of healthcare delivery systems. Their practical tasks include encouraging women to give birth in hospitals, bring their children to immunisation clinics and embrace family planning. They administer first aid to treat basic illnesses and injuries and help improve hygiene and village sanitation. The ASHAs also assist with out-patient treatment or admissions by escorting pregnant women and children to the nearest assigned health facility. This would be a primary health centre (PHC) for communities numbering 20,000 to 30,000 or a community health centre (CHC) for populations of 80,000 to 120,000 (covering 4 PHCs) with 30-bed provision.

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However, their work is complicated by a wide range of obstacles. Each ASHA has to cover a target population of 1,000 on the plains and 500 in desert, hilly or tribal areas. Only one Auxiliary Nurse Midwife (ANM) is provided for a population of 5,000, which means one ANM usually supervises five ASHAs. She holds a weekly or fortnightly meeting with the ASHAs and gives them on-the-job training. ASHAs can also draw on the support of a village-based Aangan Wari Worker (AWW) under the Integrated Child Development Scheme (ICDS) run by the Ministry of Women and Child Development. Moreover, an ASHA has the daily problem of covering a great deal of difficult terrain, mostly on foot and often loaded down with registers, weighing scale and information, education and communication (IEC) materials needed for interpersonal communication with beneficiaries. No wonder that some ASHAs become less fastidious and the delivery of services suffers, especially the counselling of eligible couples.

With the aid of IEC, ASHAs are required to find out whether a woman is underweight, anaemic or in any way physically unfit and establish who requires medical attention. But due to the practical difficulties they face, they are often unable to communicate effectively. In some cases, too much time passes between identifying an alarming symptom and initiating a medical response. Besides, there are several bottlenecks in the health monitoring system, including:

- **Multilevel entry by different people:** ASHA's are themselves a primary source of health data. Information is passed on to the Auxiliary Nurse Midwife, who in turn sends it to the Primary Health Centre (PHC) where it is filed by a data entry operator. This multi-level handling of information sometimes leads to errors and delays in data reporting.

Tablets PCs help health workers to input, manage and transfer the data.

Photos: A. Mathur

- **Health Supervisors turned data entry operators:** Some of the data entry operators in the PHCs were actually appointed as Health Supervisors, who are supposed to solve the queries and provide supportive supervision to ASHAs. However, with time spent on performing data entry work at the PHCs, the supervision part of their work has increasingly taken a back seat.
- **Making action plans:** ASHAs need to refer to the records regularly in order to fix next day's visits with the beneficiaries. This is a cumbersome task that prevents many visits from occurring at the scheduled time.
- **Timely incentives to ASHAs:** Some ASHAs do not receive their monthly payments on time, leading to a lack of motivation and less interest in working more efficiently.
- **Tracing and tracking the data entry point:** As yet there has been no tracking and monitoring system capable of finding out whether the data given by the front-line workers is authentic or where it was recorded.

In order to provide the rural front-line workers with a technology to make their communication with village beneficiaries more effective, the United Nations Children's Fund (UNICEF) field office for Rajasthan, with the assistance of the Indian Institute of Technology (IIT), Jodhpur, designed an innovative approach called e-ASHA. It consists of tailor-made application software that offers a more efficient way of identifying, tracking and monitoring mother and child health. It was decided to field test the concept and approach in a difficult-to-reach cluster of remote villages with fewer facilities, and with the set of those ASHAs who were comparatively less literate and more deprived of exposure to the outside world. Jasol Village was identified for this purpose. It is located in Balotra Block of Barmer, one of the difficult-to-access desert districts in Rajasthan. Given its tough terrain and hard location, Jasol Village was likely to have a low success rate for any innovation trial. It was believed that if the innovation was found to be successful in such an area, then it could be easily replicated in other less difficult parts of Rajasthan. The test started initially with 25 ASHAs, covering a population of 40,000 individuals in 2013.

Salient features of e-ASHA

The tool was designed to reduce the burden of the rural front-line workers, while also advancing their planning and communication skills. This would eventually improve the quality of counselling and institutional deliveries and ensure regular ante-natal check-ups, timely vaccinations and post-natal care. The salient features of this innovation are as follows:

- **Digital entries:** All the information that the ASHAs were required to record in their bulky registers can now be entered in a tablet PC that weighs much less and is easy to operate.
- **Pre-loaded tool:** The application software has a pre-installed questionnaire which helps the ASHAs to recall the issues that were discussed with beneficiaries. The responses can be entered, and the application software generates pop-up messages that give an alert if a pregnant women has any kind of anomaly in their present health condition.
- **Questions linked with audio-visuals:** The audio-visuals are linked to certain questions that assist the ASHAs to conduct efficient interpersonal communication sessions and create better health awareness among beneficiaries. They deal, for instance, with ante-natal care, appropriate haemoglobin or timely vaccinations of pregnant woman.
- **Offline and online data entry facility:** The data can be entered both online and offline by ASHAs, which helps resolve the issue of net connectivity. The system also avoids the errors entailed in multi-level handling of information.
- **Health Supervisors free for supportive supervision:** Most of the Health Supervisors, who have had to perform additional data entry tasks, will be free to resume supportive supervision and facilitate ASHAs in their job.
- **Automatic generation of action plan:** Automatic generation of the next day's schedule of visits helps ASHAs communicate better with a beneficiary. They now know beforehand whether they will be counselling for ante-natal care (ANC) or post-natal care (PNC) or performing what is called Integrated Management of Neo-Natal and Child Illness (IMNCI).
- **Reminder service:** The SMS reminder service alerts both the ASHA and the beneficiary. It tells them that a ANC/PNC or IMNCI appointment is due. This is auto-generated through the server.
- **Alert signs:** Repeated pop-up messages give alerts while data is entered on pregnant women, thus improving the capacity of ASHAs by telling them whether the respondent has a nutritional deficiency or is suffering from a medical condition.
- **Authentic data generation and transmission:** Regular software updates help in gathering accurate information from respondents. Since the information is entered where the beneficiary lives, the data can be generated and transmitted in good time.

The ICT tool ensures that no child or mother goes untracked.

The Indian Institute of Health Management Research (IIHMR) was involved in capacity building among the front-line health workers. During summer training courses, IIHMR interns at UNICEF worked assiduously with ASHAs in the villages for a month and taught them how to use the technology effectively. They gave both on-job and classroom training to ASHAs and

worked upon improving staff communication skills and proficiency with the tablets. ASHAs who were only functionally literate have now become very adept at working with the tablets.

The role of the Government of Rajasthan has been very encouraging here. During the trial the government officials concerned were always kept in loop through formal and informal discussions. From time to time they were updated on the progress being made in the project. The government officials supported the idea and its implementation. At the end of the test phase, the Accredited Social Health Activists were invited to demonstrate their acquired skills and capabilities at the Institute of Technology in Jodhpur to high-ranking politicians, including the President of India, ShriPranab Mukherjee. The policy makers were very impressed with the outcome. The ASHAs showed improvement in their confidence level with effective interpersonal communication, easy and assured data entry skills and the ability to automatically generate reminders to facilitate an action plan. The ICT tool ensures that no child or mother goes untracked, makes register entries much easier and allows ASHAs to carry less weight.

Overcoming hurdles

Of course, in spite of the positive examples, some problems were revealed in the course of implementation:

■ **Scepticism:** At the beginning, there was a mood of disbelief concerning the value of this innovation. People were of the opinion that ASHAs who were not literate enough to maintain their records would not be able to use ultra-modern tablets. But the vision of the initiators is much broader. They work on the premise that "technology is not literacy-bound", arguing that if a young child with little literacy can use the latest technology, why shouldn't ASHAs?

■ **Technology fear:** Generally speaking, people are scared of using new technology and gadgets. In this trial with tablet computers, some people took the view that an ASHA would mishandle the equipment. They were also worried about who would bear the costs if anything went wrong. It is a risk that was willingly accepted by the initiators, who maintained that, with a relatively small number of devices, no major, let alone unbearable, loss would ever be incurred.

■ **Availability of electricity:** Electricity is required for charging the tablets. In Rajasthan, 99 per cent of villages and 44 per cent of households are electrified. However, this does not actually mean there are 24-hour electricity supplies the whole year round. ASHAs with access to a power supply can charge the tablet at home, but electricity will remain a problem. Solar chargers could be an option.

■ **Repair of the tablets:** Service and repair of electronic equipment is an issue that needs addressing in a culture that encourages a use-and-throw-away attitude. The possibility of training entrepreneurs to service and repair the tablets could be explored. Another option would be for Bharat Sanchar Nigam Limited (BSNL), a state-owned telecommunication company, to replace the tablets at a minimum charge and recuperate the remaining cost from its corporate social responsibility funds.

As a result of the presentation at the Institute of Technology in Jodhpur, the politicians concluded that the Government of Rajasthan should adopt this innovation and initiate a phased roll-out in other rural areas. Whether this actually happens will depend on the policies to be adopted by the newly elected state government.

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