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Center for
Development Research
University of Bonn

ZEF Policy Brief No. 25

Bio-economy in developing countries

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The bio-economy concept

A bio-economy comprises the knowledge-based production and use of biological resources to provide products, procedures and services in all economic sectors. Every country in the world thus has a bio-economy, even if the characteristics of individual bio-economies vary significantly globally. Modern bio-economy concepts aim to "biologize" the economy with the aim of sustainable development.[1] In this respect, there are numerous overlaps with the scientific and sustainability strategies of many countries as well as with the "green economy" concept.

Various criteria can be used to assess a bio-economy. Generally, it does not matter to what extent a national economy is based on the production or use of biomass. A sustainable bio-economic development path can, for instance, also be pursued by using lower quantities of scarce types of biomass more efficiently or by substituting unsustainable biomass uses with non-bio-based alternatives. Alternatively, biological principles in processing or service sectors can contribute to value creation without having a relevant influence on biomass flows. An example of this is the increasing biologization of the pharmaceutical industry.

In developing countries, the bio-economy often relies heavily on bio-based primary sectors such as agriculture, forestry or fisheries. Often, these sectors have considerable potential for promoting sustainable growth through a transfer of knowledge and technology. Some

[1] German Bioeconomy Council (2016) Recommendations for the Further Development of the "National Research Strategy BioEconomy 2030".

June 2017

developing and newly industrialized countries, such as China and Brazil, use biomass as a modern source of energy and fuel to a greater extent than many industrialized countries. In the past two decades, international trade dynamics have resulted in developing countries increasingly also serving the European market for agricultural products. This increasing connectedness of bio-economies in industrialized and developing countries comes with opportunities and challenges, which are discussed in this Policy Brief in the form of selected examples.

Bio-economies in developing countries

Historically, bio-economies in modern industrialized countries have undergone various development stages, which were characterized by their decreasing macroeconomic share (see also Fig. 1), despite technical progress in agriculture and other bio-based primary sectors. On the other side, transformative processes, such as digitalization and biotechnology[2], represent opportunities to increase bio-based value creation in many, if not all, other economic areas. Developing countries have so far only partially benefited from such opportunities. Especially in Africa, many countries are characterized by a comparably high dependence on agriculture. Nevertheless, the contribution of agricultural primary production to added value in downstream economic sectors in poor developing countries is not necessarily greater than in emerging and industrialized countries (see Fig. 1, upper section). Moreover, agriculture and other bio-based primary sectors in many developing countries suffer from productivity deficits (so called yield gaps) attributable to political and institutional factors as well as technical barriers. As a result, these countries tend to be net importers of food energy (Fig. 1, lower section), above all in Africa. No African country exports more than 15% of the local food energy; instead, the continent is increasingly dependent on imports.

And yet, Africa boasts great potential for significantly increasing both bio-based value creation and the intersectoral and international integration of agricultural production in the near future. The required productivity increases will depend, however, on close collaboration with emerging and industrialized countries. Technology transfer and investments are an important area for such collaboration, because low-income developing countries have limited capacities in education and research as well as in knowledge-based sectors, such as the chemical and pharmaceutical industry. As an example, Table 1 summarizes corresponding key figures for countries with bio-economic development potential in Southeast Asia (Malaysia), Africa (Ethiopia) and South America (Brazil). There are great differences here in comparison with Germany, but also between developing and newly industrialized countries, in terms of renewable energies, university education, and research staff. Accordingly, the bio-economically relevant political and research strategies in countries with a stronger research and education infrastructure are more ambitious and comprehensive.

[2] To be understood here as an interdisciplinary economic branch that concerns itself with the use of biological principles in technical applications.

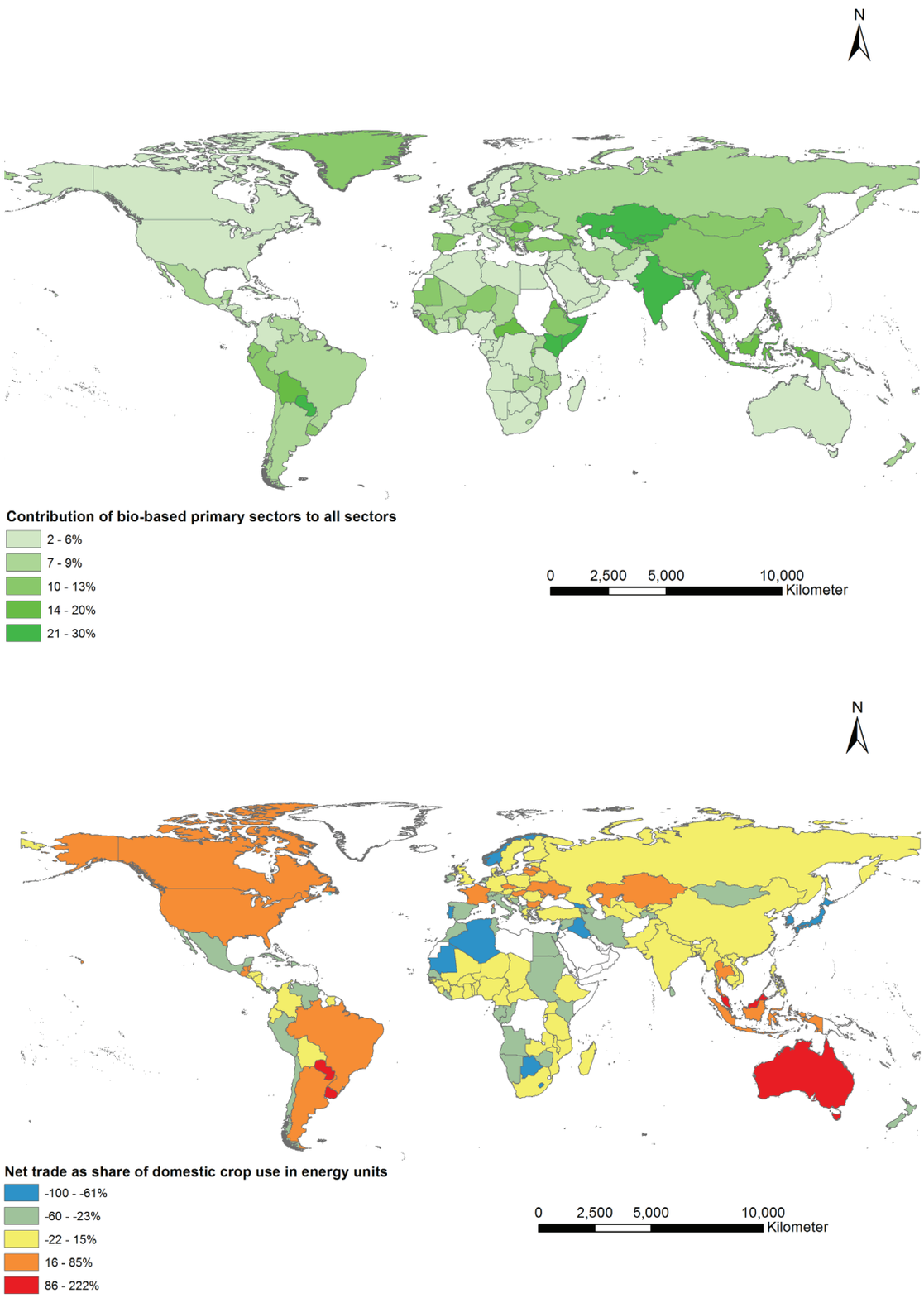

FIGURE 1:
Global comparison of bio-economies. Top: Importance of supply from bio-based primary sectors to all sectors of a country as an indicator of the importance of biomass as a production factor in the economy as a whole. Bottom: Importance of trade with crop plant biomass: negative values correspond to an import orientation and positive values to an export orientation[3]

[3] Fig. 1 (top) based on calculations by Martin Bruckner (WUW). The EORA MRIO database was used (http://www.worldmrio.com/). Monetary supplies (including imports) from agriculture, forestry and fisheries sectors (bio-based primary sectors) to all sectors of a country were measured with the total value creation of every sector. Fig. 1 (bottom) based on calculations by Arnim Kuhn (University of Bonn). Agricultural production data from the FAO and energy conversion factors from literature were used. There is no or only an insufficient database for missing countries.

TABLE 1: Bio-economic indicators for Germany and selected developing and newly industrialized countries

	Germany	Ethiopia	Malaysia	Brazil
GNP per capita (USD PPP)	47,033	1,774	26,141	15,690
Human Development Index (0-1)	0.92	0.44	0.78	0.76
Share of agriculture in GNP	0.8	41.9	8.9	5.2
Share of intermediate inputs from bio-based primary sectors* (%)	5	13	8	8
R&D researchers per 1 million employees	4078	42	1467	698
University enrolment rate (gross, %)	66	8	30	46
Renewable energy in final consumption (%)	12	93	7	44
Orientation of national knowledge-based bio-economy strategies	Cross-sectoral bio-economic development	Focus on bio-fuels	Cross-sectoral bio-economic development	Focus on high-tech bio-energy and biotechnology

**Agriculture, forestry and fisheries / Data sources: SDG Index & Dashboard, World Bank Open Data*

On the other hand, some developing and newly industrialized countries are involved to an above-average degree in important bio-economic areas such as the production and use of bioenergy and the bio-based recycling economy. Brazil and China, for instance, are among the world's largest producers of electricity from biomass, and Thailand grew by 1270% in this area between 2000 and 2013[4]. Above all, Brazil is the world's number 2 producer and consumer of bioethanol and biodiesel after the USA. In contrast to this, many African and Asian developing countries use biomass extensively, but also very inefficiently for open-hearth heating and cooking, with far-reaching negative consequences for the environment and health.

The recycling of paper is one of the most important areas within the bio-based recycling economy. After the USA, China recycles the largest quantities of waste paper, closely followed by other newly industrialized countries such as Brazil, Mexico, India and Indonesia. Even if industrialized countries usually have stronger international links due to larger trade volumes and scientific and technical partnerships, some developing and newly industrialized countries are also beginning to participate in global value creation chains to a greater extent, and build the necessary scientific networks to support such activities. Consequently, increasing numbers of developing countries are developing national bio-economic strategies in order to strengthen particular competitive advantages (e.g. agricultural location factors) or eradicate specific obstacles to development (e.g. limited scientific capacities in the high-tech field).[5]

[4] World Bioenergy Association (2016) Global Bioenergy Statistics.
[5] German Bioeconomy Council (2015) Bioeconomy Policy (Part II) – Synopsis of National Strategies around the World.

Sustainability opportunities and -risks of bio-economic change in developing countries

As any technology-based transformation process comes along with opportunities and risks, so does the bio-economy. The debate on the merits of biofuels over the past decade has shown that substituting fossil fuels with bio-based fuels can lead to competition with food production in terms of the use of land, yet also lead to the provision of ecosystem services. Especially in countries with strong external trade relations in agriculture and forestry, domestic markets are exposed to international price fluctuations, which can lead to inter-continental shifts in land use, i.e. indirect land use change (iLUC).

Figure 2 illustrates possible causal mechanisms, through which bio-economic transformation can have a positive or negative effect on sustainable development goals. Bio-economic transformation is understood here as a reaction to global trends, such as population or economic growth, or climate change. Societies both in developing and industrialized countries react to these trends with adaptation measures, such as technological innovation and political programs, which influence consumption and production decisions in diverse, sometimes also unexpected ways. Global trade and a transfer of knowledge and technology play an important role as mechanisms here. Changes in the supply and demand of bio-based goods and services in individual countries and regions have an effect on demand for production fac-

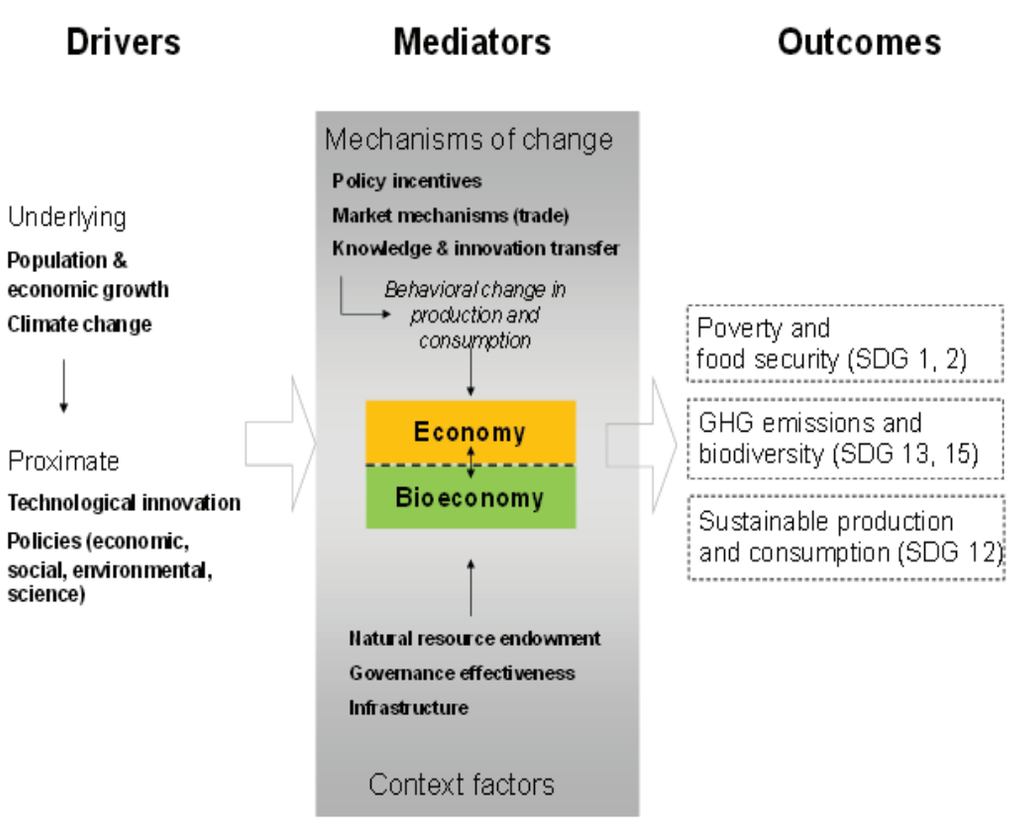

FIGURE 2: Mechanisms of bio-based transformation

tors such as land or workers in other parts of the world via the global trade system. At the same time, besides achieving the desired development effects, the transfer of technology and knowledge in regions of the world with weak social and environmental governance frameworks can also lead to negative effects on marginalized population groups and sensitive ecosystems. Assessments of such impacts are still subject to a great deal of uncertainty.

Conceptually we can distinguish four scenarios of bio-economic transformation and corresponding chains of effect that are important for developing countries:

1. Substitution of fossil fuels with bio-based raw materials: Besides bioenergy, biomass could increasingly be used as a basis for materials (building materials, plastics), or to manufacture platform chemicals in the chemical industry. The increased demand for bio-based raw materials (including biofuels) could lead to increased demand for agricultural products and land, e.g. in countries such as Malaysia and Brazil (see Table 1). While agriculture in developing countries generally benefits from such a development, this scenario poses a risk for food security in poor urban sections of the population and can have a negative effect on the emission of greenhouse gases and biodiversity in sensitive tropical and sub-tropical ecosystems by expanding agricultural production areas.

2. Profit-increasing innovation in agriculture: Technical progress in agriculture can enable a more resource-efficient production of food and can thus also contribute to alleviate land-use conflicts in bio-economic transformation processes. However, the dissemination of yield-increasing technologies, above all in developing countries, can also be associated with environmental and health risks. In developing countries, there are often also technical and institutional barriers that limit the dissemination of innovative technology, above all among small farmers.

3. More efficient use of biomass (e.g. recycling economy) is a promising area of growth in the bio-economy. Both in developing and industrialized countries, great efficiency gains can be achieved, for instance in the energy, food and construction industry or the waste economy, through the recycling of biological residual materials and the systematic (cascading) use of a wide range of biomass components. Possible rebound effects, i.e. increased demand for end products through the increase in efficiency, pose a risk, but are often lower over the long term than the expected positive effects on resource management. However, enabling and regulatory governance is often required here, too, in order to facilitate the transfer and sustainable use of technology developing countries.

4. Biomass-independent application of biological principles: Many economic areas, such as the pharmaceutical industry, as well as the transport economy, can tap into new market potential by applying biological principles and increase their value creation without having a great influence on bio-economic materials cycles. However, industrialized countries with high-level training and research infrastructures have a competitive advantage over developing countries. Besides the opportunities of this form of bio-based transformation, development risks associated with an un-

equal initial position for the biologization of technological processes and value creation chains must therefore be taken into account in the assessment.

Naturally, the bio-economic transformation paths described here are not mutually exclusive. Often, countries pursue several strategies at the same time in cross-sectoral bio-economic strategies (see Table 1). A better understanding of the factors that favor or eliminate certain transformation paths requires further research. It is nevertheless clear that existing regulatory and support tools, for instance in agricultural, environmental and scientific policies, are not always sufficient in order to optimally exploit the opportunities of the bio-economy and minimize possible risks.

Challenges for development cooperation in support of a positive bio-economic change in developing countries

The bio-economy in developing countries and possible bio-economic transformation scenarios require commitment beyond the agricultural and (bio) energy field. In developing countries, too, there is great bio-economic transformation potential both inside and outside the agricultural sector. Leveraging this potential requires cross-sectoral or "nexus" approaches to support and regulate innovation processes across economic sectors through life science research, outreach, and policy.

In the agricultural and rural energy sectors, innovation in the use of bioenergy and the provision of decentralized energy systems could alleviate tradeoffs resulting from the limited availability of labor for agriculture and biomass-energy collection.

In this as well as many other fields of application for bio-economic technologies, institutional and technical barriers to the transfer of technology and knowledge remain in developing countries. Here, state and civil society actors must engage in innovation partnerships that mainstream social and environmental safeguards along whole value chains and beyond national borders.

This Policy Brief is based on ongoing work in the projects “Forests in the global bioeconomy: developing multi-scale policy scenarios” (financed by the BMZ) and “Sustainable Trade and Innovation Transfer in the Bioeconomy” (financed by the BMBF).

The Policy Brief was developed with the support of the Federal Ministry for Economic Cooperation and Development (BMZ).

IMPRINT

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