Responsible Bioplastics

Sustainable Sourcing and the Circular Economy

bfa

Bioplastic Feedstock Alliance

Summary

A report by WWF Denmark concluded that "Creating a new economy seems an overwhelming task...However, if we have the courage to rise to this challenge and alter our perspective, we will see that certain technologies and sectors have a potential to help us take the important steps on the path toward sustainability. Industrial biotechnology is one such sector" [1].

To build a future where people, nature, and the economy can all thrive we will need to make changes to the way we interact with our resources. While the ultimate goal is a sustainable future, responsible sourcing and adopting circular systems are powerful tools to help us achieve this goal. Sourcing materials responsibly to protect the ecosystems we rely on is critical, and using those materials more than once means we can do more while demanding less. The Bioplastic Feedstock Alliance (BFA) believes that by supporting a system of continuous improvement for biomass production, we can build healthier, more resilient ecosystems that provide improved ecosystem services to local communities and better protection from a changing climate – while still providing the materials our global economy needs to function and maintaining food security.

Bioplastics and biomaterials represent a shift to a bioeconomy – an economy where goods are made from responsibly produced biomass. BFA supports this shift, because it represents an opportunity to use renewable carbon, reduce the impacts of our dependence on fossil resources, and contribute to the reduction of CO_2 emissions that contribute to global warming. Realizing the benefits of responsible sourcing will also make our farm land and ecosystems more resilient.

Plastics and other materials derived from fossil resources are currently integral to our economy's function, but our current reliance on oil, natural gas, and coal has serious and lasting consequences to both human health and the environment. Many of these impacts, like greenhouse gas emissions and resource depletion, are inherent to fossil resource extraction, and therefore unavoidable as long as we continue to depend on these materials. Furthermore, acute events like oil spills often damage both ecosystems and economies. Biobased products represent an opportunity for positive change, but that does not mean that they are free of environmental impacts. Biomass production can also have significant impacts on the environment, which is why producing responsibly is key to realizing its true potential.

Most impacts are concentrated at the beginning phase of the lifecycle for biobased products, so responsible sourcing is critical to benefitting from their renewable nature. Currently, the most common feedstocks for biomaterials are agricultural commodities, and today's agriculture continues to have serious impacts on the environment. However, it is possible to mitigate the risks and impacts of agriculture by adopting responsible practices.

Choosing feedstock and sourcing practices that respect both our ecosystems and the rights of individuals, and do not create food insecurity are critical to the beginning of the bioplastic lifecycle, but to achieve true sustainability we must ultimately reduce the demand on our planet by doing more with less. Embracing the circular economy – where goods and materials are used multiple times for a variety of purposes – is key to achieving this.

Bioeconomy and Circular Economy: The Wider Context

The bioeconomy is an essential component of the circular economy, as it provides the resource base for a vast amount of economic activities. The circular economy is defined as an economy that is restorative by design – where material flows are captured and re-used, and biological flows are designed to re-enter and replenish nature safely. We cannot realize the circular economy without the bioeconomy, because it is not currently possible to sustain an economy without any new resources being added. This is especially true when the population continues to increase. Figure 1 illustrates the circular economy and the interconnected nature of the biosphere (biological systems) and the technosphere (technical systems). The Ellen MacArthur foundation has created an interactive illustration of the circular economy which explains the concept in more detail. It can be accessed at: http://www.ellenmacarthurfoundation.org/circular-economy/circular-economy/interactive-system-diagram [2].

Figure 1- Illustration of the Circular Economy, with Biosphere (left) and Technosphere (right)

We can realize an economy which is much more circular than today, where the vast majority of products and materials that we use are recovered and recycled to make new goods. These recycled and reused materials will then be part of a cascading-value system, where materials are recycled multiple times until they are too degraded to make new materials, and then go to other industrial processes. Some materials, like aluminum and glass, are infinitely recyclable with no degradation. However, because most materials degrade, we will still need sources of new material.

Developing products and materials that are sourced from responsible renewable materials means that we will be able to maintain the circular economy without relying heavily on the extraction of finite resources, while minimizing the impacts of growing renewable materials. The bioeconomy and by extension, biobased materials, fill a need of the circular economy: to replenish a small but vital amount of resources that cannot be re-circulated sustainably.

Setting a High Bar for Sustainability

In order to assess how any biomaterial (including bioplastics) affects our planet, it is necessary to first define what an ideal bioplastic would accomplish. An optimal bioplastic feedstock is one that [3]:

1. Is legally sourced, conforms to Universal Declaration of Human Rights (UDHR) and is produced in a safe and healthy way for workers and surrounding communities
2. Is derived from renewable biomass whose production is sustainably managed
3. Does not adversely impact food security and affordability, and maintains or improves social and economic conditions along with ecosystem services in producing communities
4. Does not result in destruction of critical ecosystems, loss of High Conservation Value (HCV) habitats, or deforestation
5. Provides environmental benefits with minimal environmental impacts

From these criteria, it is then possible to examine a bioplastic's environmental, social, and economic impact on a more detailed level, and see how it measures up to the ideal. All feedstocks will have advantages and disadvantages, so the focus should be not on finding a perfect feedstock, but on committing to the continuous improvement of the best available option for that technology and sourcing region. This must be considered in the context of the evolving bioeconomy where a wide range of industry sectors will use bio-based resources.

Figure 2- Product Lifecycle Stages [9]

Bioplastic Lifecycle

The major difference in the lifecycles of bioplastics and conventional plastics occurs at the very first phase in production: resource extraction. While oil, natural gas, and sometimes coal are extracted to make conventional plastics, today bioplastics come mostly from agricultural activities.

This means that the major difference in the impacts of bioplastics versus conventional plastics occurs in the resource extraction phase of the life cycle.

The impacts of the materials through the processing, manufacturing, distribution, and use phases are generally very similar for both bio-based and fossil-based materials, although energy intensity can vary. However, the impacts at end of life may be different for some bioplastics.

Food Security

While ever more attention is devoted to the question of whether there will be enough food to supply the world's still fast-rising population, it is clear that responses to the challenge of food security must embrace questions beyond simply the number of calories being produced. Food security is for example linked with people's nutrition and whether they can afford food, irrespective of the quantity being grown. Food security is also linked with questions that are not directly connected to farming and diets, including the impacts of climate change.

As far as current food security is concerned it is important to note that today farmers produce enough food for everyone on the planet to meet their needs [1], and yet about 800 million people remain undernourished [2]. During 2008 this number rose to about one billion due to high prices on global commodity markets. This was in part caused by high oil and gas prices but also the impacts of extreme weather, a factor that increasingly affects food prices.

For example the severe drought experienced in the United States during 2012 dramatically affected corn harvests. US corn stockpiles fell by 48 per cent in just 4 months resulting in increased prices across the world. Volatility in global markets and people's access to food is shaped not only by environmental factors and farming methods, but also a number of factors influenced by governments.

These include import and export policies and tariffs, price controls, and subsidies and also the extent to which governments permit investors from other countries to take control of land under their jurisdiction. Then there is the matter of land rights, how these are sometimes often not well defined or enforced (especially in some developing countries) and the extent to which this can have compounding effects for people, especially small-holders using land to produce food.

These factors can combine to create conflict and unrest. Between 2007 and 2009 riots linked with high food prices occurred in about 60 countries across the world. This is perhaps not surprising when in some poorer countries 70 percent of household income is typically needed to buy food.

So how might the world move toward a more secure food system? Many experts conclude that a large part of the answer lies in strategies to create food systems that are capable of withstanding shocks and then recovering from them. Steps in this direction include more diverse farming and the empowerment of small-holders who are better able to use their local resources, including soils and water management practices that are more resilient to climate change.

These and other strategies will succeed more quickly when farmers receive market and policy signals that encourage farmers to take a different approach. Buyers of agricultural commodities and governments have big roles to play, although they will need to move beyond simple price and production-based measures to succeed. The reduction of food waste will also help, for example through improving storage and distribution facilities. On top of this on-going programs to combat poverty will determine longer-term outcomes for food security.

The Bioplastic Feedstocks Alliance is paying close attention to the complex question of food security and is examining ways in which the further development of biomaterials industries can contribute to minimizing risks to food security.

Bioplastic & Biomaterial Feedstocks

People have always relied on the land to provide materials, and we continue to do so today. Traditional biomaterials like wool, cotton, and wood are important to our economy and our everyday lives, and they need land to be produced. Bioplastics are a new addition to these materials, but the same motivations exist for producing them as more traditional biomaterials.

Bioplastic Feedstocks are generally divided into first generation (traditional agricultural crops), second generation (cellulosic crops as well as residue and agricultural waste products), and third generation (non-traditional organisms like some forms of algae and non-agricultural wastes).

However, when evaluating a feedstock, it is the feedstock's impacts on the environment and people that matter, not its "generation" classification. BFA is feedstock and technology neutral, but has set criteria for the evaluation of feedstocks. Also important to the performance of a feedstock is the availability of resource efficient technologies that can convert that feedstock into a bioplastic, chemical, or other material with minimal energy, water, and other inputs while delivering performance which is at par with their fossil-based equivalents. These technologies must also work at scale, as this is the only way industry will ultimately shift to a more sustainable path.

There are many factors that contribute to the performance of a feedstock. Agricultural systems – whether comprised of large scale farms or smallholders - are complex, and their interconnectedness with local economies adds another layer of complexity. Therefore, it is important to take a holistic view of feedstock cultivation, including tradeoffs between environmental, social, and economic factors. Food security and land use are particularly complicated, and also critical to responsible production.

As discussed above, food security depends on many factors beyond how much food is produced. While there is a public perception that growing food crops for non-food uses will cause food insecurity, growing non-food crops for the same purpose can have the same food security risks, largely due to land use impacts.

Land use efficiency (the amount of land needed for a crop vs. its yield) is a critical indicator that influences not just how the cultivation of a crop will affect food security in a region, but also ecosystem services, biodiversity, and the potential to drive direct and indirect land use change.

For example, it would take 37 Ha of corn to produce 100 tons of the bioplastic polylactic acid, but 588 Ha of castor oil plant to produce the same amount of a different bioplastic (bio-polyamide) [4]. In this case, it would take significantly more land area to produce the bio-polyamide. These two plastics have very different properties and are generally used for different applications, but the disparity in the land area needed to produce the same amounts of each material illustrates the effect that land use efficiency of feedstocks can have on the landscape. This is important to note, because in general, commodity food crops currently have higher yields than less conventional alternatives.

However, this is far from the only factor that must be considered. The properties of the bioplastic and the needs of the intended application are a critical factor that influence the ultimate environmental impacts of the system. Bio-polyamide, for example, can be used for technical applications that polylactic acid cannot due to its superior barrier properties. The picture also becomes less clear when considering crops grown on degraded land, or the utilization of co-products and residues. Efficient utilization of biomass coproducts and byproducts is also an increasingly important factor in optimizing land use. Furthermore, conditions in the growing region are important, which is why it is necessary to evaluate how the cultivation of a bioplastic feedstock will affect the food security and land use at a local level.

Because of the complexity and interconnected nature of these issues, it is clear that neither the "generation" designation of a feedstock, nor whether it is a food crop can be relied upon to predict effects that cultivation of said feedstock will have on the critical issues of food security and land use change. Ultimately, feedstocks must be evaluated on their regional specific impacts, advantages, and tradeoffs, as generalizations will not lead to the desired results, and ultimately healthy biomass production systems. An informative discussion about the issue of food vs. non-food feedstocks can be found in the paper "Food or non-food – which agricultural feedstocks are best for industrial uses?" [5].

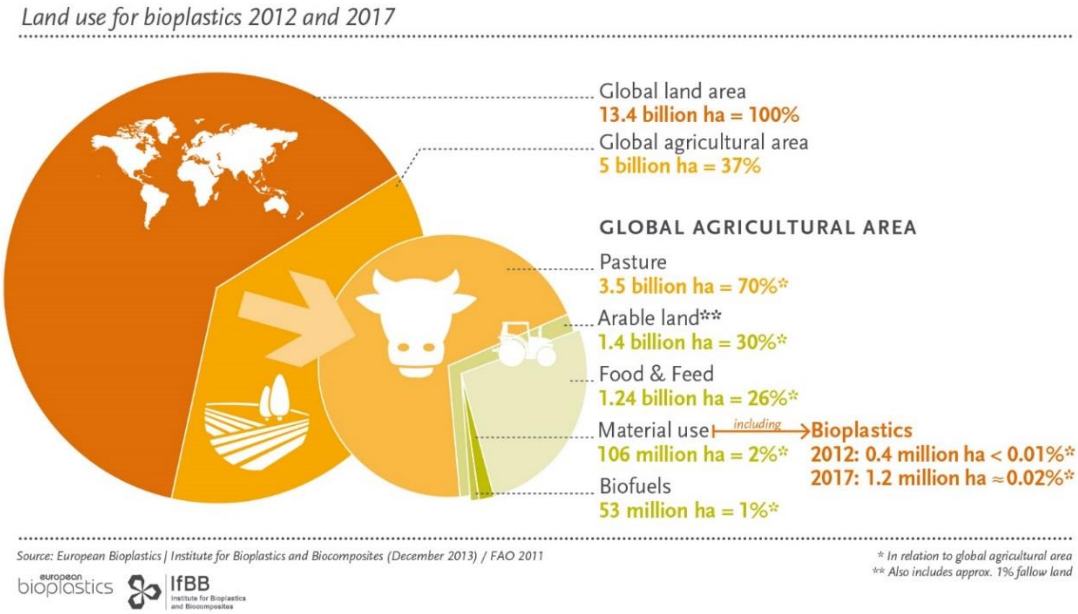
Food security and land use change are only two of the environmental and social issues pertinent to biomaterial feedstocks. Below is a more extensive list of issues related to feedstock production, and further information about evaluation and selection of feedstocks, including overviews of the issues listed below, can be found in the "Methodology for the Assessment of Bioplastic Feedstocks" [3].

- Food Security
- Biodiversity
- Ecosystem Services
- Land Use Change Impacts
- Legal Production
- Local and/or Indigenous Communities
- Occupational Health & Safety
- Soil Management
- Water Management
- Chemical Use: Nutrients and Pest Management
- Co-Product and Waste Management
- Cradle to Gate GHG
- Labor Rights

With the increased pressure on land that is predicted as a growing population demands more, it is more important than ever to use arable land efficiently and make thoughtful choices about what we grow where. There is serious concern that we will not have enough arable land to meet everyone's needs. This makes it critical that all land use, regardless of scale, is responsible.

The Institute for Bioplastics and Biocomposites and European Bioplastics have collaborated to research exactly how much land is projected to be used for bioplastics and biomaterials in the near future. For 2017, it is estimated that bioplastic feedstock cultivation will account for only ~0.02% of arable land under cultivation, as illustrated in Figure 2, below [6]. Note that the area of bioplastics is called out to the right, as it is too small to depict visually. However, despite the small land-needs predicted, it is crucial to ensure robust assessment methods to ensure that bio-based plastics are sourced responsibly.

Figure 3 – Land use for bioplastics and biomaterials 2012 and 2017



Currently, bioplastics are not a significant user of land, and they are not predicted to become so in the near future. However, the impacts of land use must still be accounted for, as any industry that uses land must be held accountable for its contribution to global land use change, no matter how small. Fortunately, tools to evaluate and minimize the impacts of land use change continue to be developed, providing insight into a path forward that could both preserve nature and support the needs of a growing population. The Low Impact Indirect Biofuels (LIIB) is a collaboration between WWF International, Ecole Polytechnique Fédérale de Lausanne (former host of the Roundtable on Sustainable Biofuels), and Ecofys [7]. The method is intended for biofuels, but is equally as applicable to biomaterials, and is a way to certify that cultivation of feedstocks do not cause indirect land use change impacts, by ensuring that feedstock cultivation does not displace other agricultural commodities [7].

Opportunity to Scale Solutions

The bioplastic and biomaterial industries are small but fast growing. They are also under significant pressure to grow sustainably, which presents a unique opportunity. By setting a high bar for production of feedstocks, it may be possible to influence not just these sectors, but the agricultural and chemical sectors as well. This is because many of the same companies that are buying biobased feedstocks also purchase other agricultural products. Indeed, these products are often sourced from the same region or even the same producers. Bio-based chemicals are also a fast growing industry that has a large amount of overlap with biomaterials in the environmental issues they face. By setting a high bar for the environmental performance of bioplastics and biomaterials, and demonstrating that this bar can be reached, it gives the emerging bio-industries a model to follow.

Bio-based ≠ Biodegradable

It is the chemical structure of the plastic, and not the origin of the material that it is made from, that determines whether a material is biodegradable, compostable, or not. Whereas biobased and biodegradable plastics both qualify under the term “Bioplastics”, a bio-based PET is not biodegradable or compostable, whereas a PLA is. When existing plastics are produced using biobased feedstocks vs fossil based, they are called “drop-in bioplastics” because they can be substituted into the supply chain of an equivalent conventional plastic without any changes to the rest of the downstream system including end-of-life. This means that if the fossil-based PET used in a recyclable bottle is substituted with bio-based PET the bottle will remain as recyclable as it was before.

Biodegradable/compostable plastics such as PLA (polylactic acid) and PHA (polyhydroxy alkanoate) are not drop-ins; they have their own unique physical properties and in addition to this they may under specific conditions be broken down by micro-organisms into CO2 and biomass.

Compostable plastics are not inherently less impactful to the environment. Many factors such the availability of compost or recycling facilities and the nature of the intended application, must be considered to determine the best material for a situation. Additionally, it is impossible to evaluate the sustainability of a material on its end of life performance alone. All stages of the lifecycle and their impacts must be accounted for in order to compare between materials.

Therefore, it is the overall impacts of a bioplastic throughout its lifecycle that must be considered. End of Life impacts are a part of this evaluation, but should not alone dictate any course of action. More information about the complexities of EOL can be found in the documents “What a Waste: A Global Review of Solid Waste Management”[8].

Conclusion

Moving to a more circular, biobased economy is a great challenge, and one that must be met in order to achieve a future where we do not demand more resources from the Earth than it can renew. To realize this goal, it is essential that we all engage in a positive dialogue focused on advancing our collective understanding of the issues and driven by stakeholder engagement. Growing a bioeconomy that is both environmentally and socially responsible is a key step towards building healthy and resilient ecosystems whose services will benefit us all.

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