

Article

Bioeconomy: The Innovative Twin of Sustainability

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Abstract: With its far-reaching promise of a new synthesis of ecology and economy, the concept of the bioeconomy is a shimmering, ambiguous term in need of ethical and conceptual interpretation. The paper identifies potentials and strategies of the bioeconomy for a knowledge-based energy and raw material turnaround, which, by turning away from fossil resources, can at the same time contribute significantly to waste prevention. The focus is on ethical criteria for a responsible bioeconomy. In terms of environmental ethics, this approach has exemplary significance because it currently represents the most prominent concept for unfolding and operationalizing the innovative side of sustainability. The paper therefore argues for an expanded concept of the bioeconomy that includes the reproductive capacity of nature, for which soil conservation is a strong example. This will be unfolded with the proposal of an ethics of innovation.

Keywords: bioeconomy; ethics; environmental ethics; innovation; sustainability; responsibility



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1. Introduction: The Promise of a New Synthesis for Ecology and the Economy

The following essay has four sections. First, the introduction takes a critical look at the way the bioeconomy is debated together with the hopes and promises associated with it (1). This is followed by an assessment of the changing history of the term, in which the normative implications of its use are of particular interest (2). Against this background, the third section formulates four central criteria that the concepts of the bioeconomy must fulfill if they are to meet the requirements of sustainability (3). The next section develops the idea of resource as a culture- and therefore creativity-dependent variable to outline an ethics of innovation (4), before the final section summarizes the conceptual consequences for an ethically responsible bioeconomy (5).

The research method that shapes the argumentation of the essay is that of a social ethics which sees itself as an essentially philosophical discipline within the context of the environmental humanities [1] (pp. 37–75). The focus is on conceptual analyses with particular attention to the normative implications of the terms used in various discourses. The argumentation is therefore not based on our own empirical research, but on a literature analysis. Ethics is understood as a normative discipline (*normative ethics* in contrast to concepts of descriptive ethics or metaethics) developing criteria for the orientation of action and the design of institutions, which is mainly shown in the third section. In the fifth section, the focus is broadened to include cultural factors such as theological references, whereby it is assumed in accordance with the method of public theology [1] (pp. 59–67) that these must and can be formulated in a rationally comprehensible way. The resulting methodological program is that of an ecological social ethics, which is characterized by a multi-layered relationship between social and ecological contexts as well as between empirical facts and prescriptive statements [1] (pp. 293–353).

Climate change and its effects pose an immediate ethical challenge to our attention as well as action. As an “ecological” process, it deeply affects and transforms the relations of human beings to their surroundings up to the scale of the earth system itself [2]. Any

effective response strategy therefore cannot be restricted to the level of the individual but has to consider the function of social structures and networks.

Given that the emission of greenhouse gases plays a central role in the anthropogenic drivers of climate change, a first impulse might be to just end emitting them and thereby preserve or “sustain” our stock of resources for future generations. However, such a merely conservative approach to sustainability proves to be incompatible with the claim of personal freedom: As human beings, we cannot simply stop to use external resources in order to form the environment and our life within it. In addition, such a commitment to pure passivity has hardly any prospect of being implemented under the conditions of liberal democracy. *Therefore, the starting point of any meaningful search for a constructive approach to the necessary politics in response to climate change has to conceive of sustainability itself as an active process, transforming the ecological relations of human societies in an encompassing horizon.* Against this background, the ethical challenge is to bridge the tensions between human economy, taken as the encompassing system of how resources are handled to allocate goods, and its ecological framework, regarding preconditions as well as limits.

One of the leading concepts in the search for a new synthesis between the economy and ecology is that of a “bioeconomy.” It can be defined as the provision and use of renewable resources as well as the integrated development of pertinent knowledge with the overarching goal to reach a sustainable subsistence strategy [3]. For an approach to environmental ethics, this bears exemplary significance for the need to focus on the *creative* exploration of new ways for the nature-compatible utilization of resources [1] (pp. 543–577). The bioeconomy can highlight this often-neglected aspect: *it can serve as a prototype to evolve the innovative side of environmental ethics.*

The bioeconomy comes along with great visions. The most important fields of its application are agriculture and nutrition. Precision farming, for example, is supposed to increase yields and at the same time considerably reduce water consumption and the use of pesticides and fertilizers. The foreseeable lack of fertile soil could be compensated by urban biofarms, which produce food for 20,000 people in a single tower block. A significant part of waste problems should be solved by means of bio-based and recyclable raw materials. Newly designed renewable resources would make it possible to replace fossil materials without any downside regarding product properties. Slaughterhouses could be closed and the need for meat could be satisfied more efficiently through biotechnologically cultivated meat fibers. Such visions need to be checked both critically and constructively [4,5]. A lot seems to be possible yet remains ethically ambiguous [6] (p. 267). Without considerable seed capital on the one hand and a normative as well as regulative framework on the other hand, it seems hardly possible to put those attempts into sustainable practice and implement them within free markets.

Moreover, “bioeconomy” is a highly ambiguous term with very different origins and understandings. Therefore, it has to be critically examined to what extent it is actually suitable for realizing ecological responsibility.

The bioeconomy stands for the technically innovative and knowledge-based side of sustainability [7] (p. 2). From the point of view of environmental ethics, it can be seen as a concept that does not primarily start with restricting and prohibiting certain actions, but above all wants to open up new spaces for design. Conceptually, the dynamics of the bioeconomy are helpful in order not to overburden expectations of environmental relief by means of moderate consumption and sufficiency. For example, if the environmental problems associated with plastic waste can be substantially reduced through recyclable and compostable bioplastics, this also strategically makes more sense than moral appeals to voluntary waivers [8]. Bioplastics combine the advantages of plastic as an extremely flexible and versatile material with the ecological benefits of a circular economy. However, if those two perspectives are simply played off against each other, rebound effects through an increase in consumption threaten to annihilate any progress towards sustainability. Rather, innovation and moderation should be seen as two necessary sides of environmental

ethics that complement and balance each other. An ethical consideration of the bioeconomy needs both dimensions.

The bioeconomy from the perspective of environmental ethics gains its profile from integrating the relationship between behavioral renunciation and innovation through creative syntheses. The aim is to regard morally well-founded restrictions in the ecological field not as obstacles to innovation, but on the contrary as prerequisites for giving innovation an orientation compatible with the wider scope of ecological frame conditions.

The bioeconomy can stand for an approach that overcomes the premature oppositions and polarizations of ecology and economy, of nature and technology, of preservation and creation, of renunciation and innovation. It unfolds the specifically technical–economic and innovation–political side of sustainability and is thus a key for the latter to be implemented in research, engineering technology and the economy [9]. However, where the bioeconomy is only considered through the narrow lens of technology and economy, it threatens to fall short of the demands of comprehensive ecological and social responsibility in many aspects and therefore requires an ethical limitation, framing or even broadening of its perspective. Where a reduction in the perception of nature to its economic (exchange) value is conceptually associated with the term bioeconomy, this poses a fundamental challenge. The economic perspective is of vital importance for the efficient and responsible use of scarce natural resources. Environmental ethics must recognize this, but at the same time be programmatically oriented to point out the blind spots of such approaches and to demand a protection of natural goods beyond short-term and fragmented, measurable economic purposes [10].

Based on this introductory outline, the following will first examine the ambivalences of the term bioeconomy and its recent political usage. Subsequently, criteria for an ethically justifiable bioeconomy will be formulated, opening the way to contours of a fundamental ethics of innovation according to the aims of an active transformation towards sustainability.

2. Conceptual Analysis against the Background of the Ambivalent Usage of the Term Bioeconomy

“Bioeconomy” is an iridescent term and correspondingly in need of interpretation. It can be read in two directions: with an accent on “bio” as the greening of the economy; or with an accent on “economy” as a program of consistent economic use of natural resources [11] (p. 372) and [12]. There are worlds between the two readings—worlds of very different concepts of value and society.

The early use of the term in the 1980s aimed at a form of the economy based on solar energy and integrated into nature’s energy and material cycles [13]. In this line of tradition, the bioeconomy can be characterized as a circular economy and understood as a precursor to the ethical model of sustainability. However, the more recent history of the term has quite different contexts. With influential figures such as Juan Enriquez, the focus shifted more towards questions of how the economy can make use of new biological knowledge for commercial and industrial purposes [14]. Such a variant of the bioeconomy follows more the paradigm of an economization of nature, in the sense of a comprehensive exploitation of nature as a biological resource.

If we look at the definition of the German Bioeconomy Council, which was founded in 2009 and advises the German government on the “National Research Strategy Bioeconomy 2030” (*Nationale Forschungsstrategie BioÖkonomie 2030*), we find a definition that is open to interpretation: “Bioeconomy,” it is said, comprises “the production, exploitation and use of biological resources, processes and systems to provide products, processes and services across all economic sectors within the framework of a future-oriented economy” [9] (p. 3). The normatively guiding term here is “future-oriented”, in German “*zukunftsfähig*”. It is used in parallel with “sustainable,” although this term is equally not defined in more detail and thus does not solve the problem of being largely open to interpretation.

At the EU level, the engineering and biotechnology sciences are the driving forces for an understanding of the bioeconomy, which is essentially focused on the promise of major economic opportunities. Thus, the potential of the bioeconomy in Europe, estimated at

around 1.5 trillion euros (!) annually, is to be specifically tapped and exploited [15] (p. 1). This is to be achieved by bringing together companies, especially from the biotechnology, chemical, pharmaceutical, agricultural and food industries, and to some extent also from the energy industry. The power of this development can be recognized in the fact that nowadays more than 60 countries work on or with some sort of bioeconomy strategy [16] (p. 140).

This is the conceptual context in which Franz-Theo Gottwald and Anita Krätzer emphasize their critique of the bioeconomy as a “totalitarian approach” (*totalitärer Ansatz*) [17]. They base their criticism, among other things, on an analysis of the EU programs launched under this title as well as on a text of the German Bioeconomy Council: Bioeconomy, they argue, stands for a new quality level of the economic exploitation of nature and thus for an absolutization of economic thinking as well as of an industrial–technological model for agriculture and nutrition. According to Gottwald and Krätzer, what the bioeconomy as advocated by the EU and the German government has in mind is the conversion of all living things into biomass as a raw material [17] (p. 8). In particular, the field of synthetic biology, which not only uses living things but also produces them technically, is ethically highly controversial [18].

The bioeconomy is closely linked to the concept of a “green economy.” As the promise of a win–win situation between economy and ecology, this has contributed significantly to the rhetorical acceptance of the sustainability strategy at EU levels. However, the price for it was high: acceptance was paid for with a reinterpretation of sustainability in terms of “green growth.” In Germany in particular, the supposed “green economy” has therefore been heavily criticized by ecologically oriented institutions and blamed for the glaring discrepancy between the promises and reality of global climate and environmental policy in the past two decades [19] (pp. 137–167). The concept is argued to downplay the extent of the necessary shift and needs to be deconstructed through a discourse- and power-critical analysis [19] (p. 13). However, such a critique does not offer an alternative concept, so that its practical value for the discussion of bioeconomy lies more in impulses for its sociological flanking and further development than in arguments for its blanket rejection. The basic idea of bioeconomy—to replace fossil with renewable raw materials and to develop and use new technologies for processing biobased raw materials—can hardly be criticized in an ethically meaningful way.

One aspect of the history of the term that can be empirically investigated is the question of knowledge and acceptance of the term among a given population. It should be noted that the concept of the bioeconomy is still comparatively little known and, in some cases—for example by environmental associations—has been strongly rejected [17,20]. In a study by Zander et al. [21], three different future scenarios for the bioeconomy in Germany were developed and empirically tested with the help of a quantitative online survey. In the individual scenarios, the elements of a bio-based economy and the renunciation of fossil resources were implemented to varying degrees, thus varying the ultimate impact on people’s everyday lives. The scenario that would bring the greatest societal transformation was favored by most. However, respondents feared a reduction in living standards as well as price increases and social injustice. Furthermore, the bioeconomy was found to be more acceptable to younger people and women than to older people and men.

Trust in biotechnological innovations as well as in the actors who are responsible for implementing them is an important factor influencing the acceptance of the bioeconomy. Trust can be built above all through transparent communication of the advantages and disadvantages of new technologies and through convincing examples of solutions to known problems [20].

There are fundamental conflicts in the bioeconomy discourse due to very different classifications of the concept. These have essentially arisen from the fact that it originated in a context of research technology but is nowadays understood much more broadly and finds important areas of application in industrial policy and, among other things, in the field of agriculture and food [9]. From an economic ethics perspective, it should be noted that neither the greening of the economy is per se good nor is the economization of nature per se bad. In this respect, both readings of the bioeconomy have their justification and their

limits. What matters is a clarification of which interpretations have their appropriate place in which contexts and where their respective limits lie. To this end, the following section proposes four ethical criteria, in order to clarify the conditions for tapping the constructive potential of bioeconomy as the innovative twin of sustainability.

3. Assessing the Criteria for an Ethically Responsible Bioeconomy

Ethical reflection can provide the tools needed to make prudent decisions. Especially within the context of modern politics, such tools can never offer a basis to simply deduce unambiguous solutions to complex problems. Instead, ethics can set up criteria as guard rails for the responsible application of a political program in accordance with normative principles. It is in this sense that this section formulates four criteria for an ethically responsible application of the bioeconomy: the need for a normative compass informed by precaution and risk assessment (Section 3.1), a differentiated recognition of the value dimension affected in nature and human interaction with it (Section 3.2), the concept of planetary boundaries as a framework for ecological resilience strategies (Section 3.3) and the special relevance of food security for a global bioeconomy (Section 3.4).

3.1. *The Innovative Power of the Bioeconomy Requires a Normative Compass Informed by Precaution and Risk Assessments*

From the perspective of environmental ethics, it is unacceptable that the term “bioeconomy” is used for a one-sided revaluation of sustainability as “green growth.” Political documents on the bioeconomy show a strong tendency to merely cite “sustainability” as an abstract term without its sufficient development in the form of binding criteria. Without such concretion, however, the invocation of sustainability remains empty and noncommittal. According to the criteria of sustainability, principles such as precaution as well as that of risk minimization would have to be reflected in their own right [22]. However, under the umbrella of the bioeconomy, an explicit discourse on risks has so far hardly been developed beyond an abstract and defensive manner, although this is urgently needed from an ethical point of view.

Since enormous growth potentials are characteristic of the bioeconomy and the concept is particularly relevant for illustrating this dimension of development, we do not reject the term “sustainable growth” in principle in the context of bioeconomy, but postulate that it should be used more cautiously and only in conjunction with a risk assessment that also includes social and systemic ecological factors. If “sustainable growth” becomes the headline of the entire concept, as is partly the case at the EU and federal level, the concept gets into a slanting position and loses its credibility for the large part of the environmental and nature associations as well as for many scientifically leading representatives of an ecological economy.

3.2. *In Order to Establish the Bioeconomy as a Responsible Concept, the Different Value Dimensions in Nature and Human Interaction with It Have to Be Acknowledged and Protected by Adequate Norms and Strategies*

Precisely because the bioeconomy is a highly innovative field of new dimensions of knowledge-based uses of nature, it needs a clear and binding value foundation. The concept of value originally comes from an economic context and from there has become a central concept of ethics [23,24]. The ethical and the economic perspectives are by no means mutually exclusive but can complement each other in a fruitful way. A differentiated perception of the different types and levels of the values of nature could, for example, help to motivate people to protect biodiversity by quantifying its economic value [25]. As an economic model, this is called the “internalization of external costs” and is vehemently advocated by numerous ecological pioneers under the slogan “ecological modernization” [26,27]. However, this economic perspective is associated with a specific restriction, insofar as nature is perceived only in terms of its real or potential market values. Therefore, the bioeconomy is only responsible if it goes beyond economic–functional valorization and also keeps in mind the intrinsic value of animals, plants and landscapes [6] (p. 274–277).

After all, nature as a habitat that supports humans and as a highly complex network of ecological system interrelationships cannot be reduced to being a warehouse for human purposes. The bioeconomy must therefore integrate the various value dimensions of nature, for example in the areas of animal, soil, water and landscape conservation, in a graduated manner through appropriate standards and strategies. It needs an ethical framework of standards of environmental and social compatibility as well as animal welfare.

3.3. The Bioeconomy Should Use the Concept of Planetary Boundaries to Identify Environmental Priorities, with Increased Emphasis on Ecological Resilience Strategies

The most important concept to empirically measure the critical parameters of sustainable development has become that of “planetary boundaries.” It uses nine indicators to analyze the planetary boundaries that must not be exceeded if resilient, crisis-resistant and sustainable development is to remain possible [28]. Contrary to public discourse, the focus is not predominantly on CO₂ emissions, but on biodiversity, the nitrogen cycle and the water balance.

The concept of *resilience* marks a pioneering contribution to concretizing the adjectives “sustainable,” “ecological” and “biological” in terms of a differentiated risk assessment. It refers to robustness in dealing with extreme processes of change [1] (pp. 412–444) and [29–31]. A stronger link with resilience research would give the bioeconomy a new emphasis: instead of the, sometimes utopian, promise of being able to achieve ecological sustainability and economic efficiency at the same time, it would primarily ask about the conditions of crisis-resistant development [32]. This is necessary given the increasing likelihood of disruptive development processes in the impact domains of climate change tipping points. International research on planetary boundaries and resilience should be given more attention as a frame of reference in the bioeconomy.

3.4. Without a Paradigm Shift in the Area of Food Security, a Global Bioeconomy Cannot Be Implemented—The Promotion of Smallholders and Soil Conservation Have Key Functions in This Context

Particularly in the field of food security, which is central to the bioeconomy, the resilience concept leads to a paradigm shift: The critical factor in the global South in this regard is not primarily the problem of quantity, but that of purchasing power and thus access to local markets and, above all, to land for own cultivation. Under the conditions of climate change, conversion to more drought-resistant cultivation and access to water are also becoming increasingly important. The aim of food sovereignty demands not only that the poor are provided with food, but also that they are empowered to feed themselves, which is much more in keeping with their dignity and at the same time has a positive impact on social and cultural development [33] (pp. 19–27). In particular, the field of genetic engineering and genome editing, which holds great potential for the bioeconomy, must not be used to bring small scale farmers into capital-intensive dependencies.

There is no single concept of the bioeconomy that can be usefully applied to all regions of the world. Western models are often capital-intensive and geared to international marketing, and thus sometimes pose more of a problem than a help for smallholder food sovereignty. Here, at least a clear shift in emphasis, if not a paradigm shift, is needed in regard to the conceptual unfolding of the bioeconomy for countries of the Global South if it is to live up to its own claim of fighting hunger and strengthening resilience in dealing with the planetary boundaries.

4. Innovation Ethics for a Resource-Conserving Bioeconomy

As a knowledge-based program, the bioeconomy requires an ethics of responsible innovation to deliberately, creatively and risk-sensitively unleash the potential of research and development for solving problems of scarcity. Methodologically, this has been reflected as the need to develop a “risk maturity” as the basis for responsible innovation [1] (pp. 421–444). A socio-culturally expanded, ecologically grounded innovation ethics sup-

ported by regulatory policies marks a promising strategic core of the bioeconomy. The goal of developing it requires fundamental ethical reflection.

The first step towards an applicable ethics of innovation is to critically assess the assumption of a “resource” as being simply a natural given. With resources considered instead as a function of cultural development, the second step can be to reorient the direction of technological creativity. From thereon, the final step of this section will focus on the conceptual connection of precaution and innovation, which marks the dynamic link between bioeconomy and sustainability.

4.1. Resources as a Culture- and Technology-Dependent Variable

The bioeconomy does not want to only preserve the resources of nature, but also wants to increase their stock. In this context, it is essential to recognize the concept of a resource as a culture- and technology-dependent variable. For it is only through the possibility of use that a substance or energy occurring in nature becomes a “resource.” For example, carbon dioxide could become a significant resource, if we learn to use it as a source of raw materials, e.g., using algae to produce carbon [34]. Moreover, previously unused biomass, often disposed of as residual material, could be used as a productive resource for the bioeconomy. Assuming an innovation- and technology-based concept of resources in this sense, the scope for a dynamic understanding of bioeconomy emerges. Through cultural, technical, social and economic creativity, new uses of nature can evolve and thus resources can be increased. However, through the loss of knowledge, resources can also lose their value or their status as usable raw materials. This is the case with many foods.

Against this background, the distinction between “strong” and “weak” sustainability related to the use of non-renewable resources needs to be clarified [1] (pp. 482–505). The plea for strong sustainability, which prohibits the substitution of natural resources, is admittedly an obvious response to the arbitrariness problem of weak sustainability, which rests on the assumption of natural functions in principle being substitutable and often underestimates the complexity of ecological relationships. However, both sides must not be overstretched: The categorically generalized prohibition of substitutions is based on a naturalistic fallacy, because resources are not only a naturally occurring stock of renewable or non-renewable raw materials, but a potential that can be multiplied by innovative ideas for utilization. In this respect, creativity is in a sense the most important resource of a sustainable society. The bioeconomy develops this component with a particular dynamic and its significance and potential would be misjudged if a biologically truncated concept of resources was presupposed.

4.2. Reorienting Technical Creativity

The bioeconomy only meets the requirements of sustainability if it is able to steer technical creativity in a new direction: The future benchmark for progress is not linear productivity growth, but resilient embedding in the complex interconnected interactions of nature. This is the yardstick by which the bioeconomy as an innovation program is to be measured. It will only develop its strength and legitimacy if and when it aims at such a dynamic concept of the creative valorization of nature with attention to the careful and efficient use of resources. There are areas where there is enormous potential for opportunities. However, these must be strategically tapped and linked, e.g., by dovetailing high-tech and sustainability strategies, by phasing out non-sustainable structures so that sustainable innovations can diffuse more quickly, by internalizing external costs as comprehensively as possible in all CO₂-intensive products and services, by using alternative indicators of prosperity, by creating framework conditions for a circular economy, by making greater use of the financial sector as a lever for sustainable innovations, by mobilizing venture capital in the field of bioeconomy and, last but not least, by providing impetus for an agricultural turnaround in favor of renewable raw material production without jeopardizing food security [7] (pp. 2–7) and [35].

Whether the bioeconomy unfolds in ethically reasonable ways or not is essentially determined by whether or not it is able to expand its view beyond abstract technical and economic maximization models, which often generate high external costs: Only if the concept includes socioeconomic and cultural contexts, e.g., in the sense of food sovereignty, and promotes them in a flanking manner, can it be evaluated as ethically positive [36]. The bioeconomy needs an innovation ethics that is primarily based on multifactorial syntheses and not on linear maximization models.

In this context, technical innovations should be more closely linked to social innovations, embedded in systemic contexts and consistently oriented towards a shift away from the use of fossil fuels. With Helmut Trischler, we hold technical change to be simply inconceivable without cultural change, for technology does not develop out of an inherent logic of its own but is socially constructed [37] (p. 29). The German WBGU (*Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen*) summarizes this under three maxims that need to be linked: a culture of mindfulness, a culture of participation and a culture of commitment [38] (p. 2).

4.3. Innovation as the Way to Operationalize Precaution

Against this background, strengthening the principle of innovation in technology assessment is highly preconditional in ethical and research policy terms. Innovation has a fundamental importance in appreciating and releasing the specific potentials of science. This is essentially due to the fact that it dares to do something new and reveals solutions to future problems in ways that could not be deduced beforehand. At the same time, it not infrequently generates problems itself for which there are no anticipatory safety strategies. However, innovation ethics must not become a “black box” as a hiding place for undefined goals and interests. This would weaken the binding nature of the precautionary principle. From an ethical and systematic point of view, precaution and innovation are not principles on the same level. Rather, *innovation is the most important operationalization of the precautionary principle in research policy*. It must be oriented in such a way that it does not undermine services of general interest but implements them. On the one hand, technical and social innovations offer unimagined opportunities for services of general interest in the knowledge society. On the other hand, services of general interest give those innovations a direction and a binding framework.

Responsible innovation needs a clear ethical definition of goals, a binding research policy and legal framework and a process-oriented formalization of decision-making procedures and participation rights. It is necessary to develop spaces for interaction and discourse as well as procedures that are suitable not only for motivating heterogeneous actors with divergent demands to constructive, cooperative interaction and negotiation, but also for enabling them to act accordingly [39] (p. 84). In the bioeconomy, which is essentially an innovation concept by virtue of its genesis in research policy, these conditions have not yet been sufficiently guaranteed.

Ethically, innovation and precaution are not to be discussed as opposites, but as two concepts that are complementary to each other. The example of new plant breeding techniques can be used to illustrate how precaution and innovation can be related to each other in normative questions of the bioeconomy. For some years now, multinational companies and industry associations in particular, but also the European Risk Forum and the European Economic and Social Committee (EESC), have been calling for “the ‘Innovation Principle’ [to] be applied in a complementary manner to the precautionary principle” [40] (para. 5.1.4) without the latter hindering innovation. According to this innovation principle, the impact of laws and regulations on innovation should be taken into account.

Particularly in the context of the treatment of genome editing under European law, this has led to a critical discussion about whether the coupling of precaution and innovation clears the way for an undermining or at least leveling of the EU provisions of the precautionary principle, which are quite strict in terms of environmental law [41]. From a systematic

ethical point of view, the postulate to regard precaution and innovation as two equally important principles that should be weighed against each other is a misunderstanding:

“If one understands the ‘innovation principle’ not as an attack on the precautionary principle or as an attempt to weaken it, but takes seriously what its proponents emphasize, namely that the ‘innovation principle’ should complement the precautionary principle, it becomes clear that the precautionary principle does not need such a complement insofar as it is, properly understood, neither inhibiting nor hostile to innovation. [...] In this respect, it is nonsensical to postulate an innovation principle that should stand on an equal footing with the precautionary principle and complement it” [42] (p. 13, our translation) [43]

Nevertheless, the idea of innovation is significant for ethics and deserves greater attention. The call for research that is both innovative and responsible, as discussed by the European Commission under the title “Responsible Research and Innovation,” has responded to this challenge with a political model that seeks to establish new principles of participatory technology assessment in order to define research goals in a way that is compatible with the common good [11] (pp. 366–368) and [44–46]. In this way, it may be possible to bring questions of the understanding of precaution closer to an ethical deliberation and thus to free them from the narrow focus of a merely scientific risk discourse. From an ethical point of view, the main question is to what extent an ethics of responsibility depends on an understanding of innovation that sees its specific approach to the topic of responsibility for the future not only in the preservation, but also in the further development and sustainable transformation [47] (pp. 63–64, 385–386, 390–393).

This issue is at the center of the ethical debate on the bioeconomy. Environmental ethics can be a guide to address precaution and innovation as two complementary strategies of self-limitation and self-development, which are not to be placed side by side as supposedly of equal rank. Instead, self-limitation is to be understood as a prerequisite of self-development. From the perspective of a temporal theory of social transformation, the conceptions of “sustainability” and “innovation” initially stand in a paradoxical relationship. While sustainability, with its dominant orientation to natural cycle theories, focuses primarily on the preservative integration of new research approaches with regard to the resources thereby called upon, the concept of innovation tends to be associated with the expectation of a biotechnologically mediated improvement in the efficiency of resource use, which allows the natural basis either to be supplemented or artificially imitated. Both aspects—natural resource conservation and technical innovation—are nevertheless not in a relationship of substitution but are to be addressed as complementary strategies of the intended synchronization of heterogeneous goods.

5. Conceptual Consequences for an Ethically Responsible Bioeconomy

The bioeconomy is experiencing high growth rates worldwide. In its function as an innovation driver, the hopes placed in it can be compared to digital companies, which have become the drivers of economic development in recent decades [48]. Intensive funding has transformed the concept from the niche of a specific research field into a guiding concept for a large area of economic and social development worldwide. As a result, the context is changing. It takes on key importance for economic development in many sectors, such as energy, raw material procurement and use, waste prevention and the use of residual materials or agriculture and nutrition. Therefore, an ethical, political and sociological reflection on the concept and its practice under very different cultural and social conditions worldwide is a desideratum arising from this dynamic [49]. In this context, ethical reflection should not only be a downstream measure of gaining acceptance but should be understood as a cross-sectional task of understanding the goals, framework conditions and actors of a strategy that is equally oriented towards innovation and tradition.

In the publications that have dominated so far, the bioeconomy presents itself as a highly iridescent concept, which not infrequently conceals issues that are ethically unclear. Due to its broadness and indeterminacy, it can easily be misused as a mere label without

any binding sustainability effect. The rejections related to this are quite understandable and have an important function in the discourse. However, there is a danger of throwing out the baby with the bath water. This is because *there is no reasonable alternative to the basic bioeconomic idea, namely the consistent integration of the economy into the cycles of ecological systems that support it, which provide the resources and absorb the residual materials.*

An ethically responsible bioeconomy will be measured by the extent to which it succeeds in effectively protecting fertile soils, clean water, forests and a stable climate—to name just a few examples—as elementary goods of the global common good. Ethics can be a fundamental broadening of horizons in this regard, helping to provide the concept of bioeconomy with the necessary normative and regulatory basis. Implementing such a concept in modern societies marks a complex challenge of its own. A special role among the cultural resources which help to improve its framing conditions can be attributed to addressing religious dimensions, since the images of human beings and perceptions of reality associated with these still form a framework by which the ideas of responsibility, prosperity and justice are oftentimes shaped in their practical application [50,51]. Despite all the differences, the various religious and secular conceptions can complement each other, not least when they point out the limits and blind spots of each other's perspectives in an open and honest dialogue willing to learn from each other [1] (pp. 268–289) and [52] (para. 163–201).

Especially in the context of a Christian environmental ethics, the reassessment of creativity and innovation in the context of the bioeconomy can also contribute to the process of reorienting religious thinking itself. Insofar as the cosmivision of Christian creation has long been associated with a rather static thinking about order in terms of natural law, it overemphasized the perspective of conserving the known and given. In light of the current ecological situation, there is a clear need to catch up here [53,54].

The model of a circular bioeconomy corresponds to the concept of Christian responsibility for creation, which, in terms of responsible ethics, relies on weighing up complex interrelationships of effects and not primarily on the tabooing of interventions in nature [1] (pp. 187–218). Christian ethics can be helpful, especially in the context of bioeconomy, in order to broaden the view beyond linear economic calculations, for example, by understanding fertile soil as a collective good that is obligated to the common good, the preservation of which must not be sacrificed to particular and short-term interests [55]. The creeping loss of fertile soils is one of the main evils of industrial civilization [56] (p. 250). The bioeconomy needs more awareness of soil as its most important, yet massively endangered, production base [55,57].

Christian environmental ethics can serve as one example for an embedding of the ethical impetus for the bioeconomy in a broad range of cultural resources. It strengthens the ethical horizon by linking it with a theology of creation, biblical ethics of responsibility, solidarity and educational work practiced by the Church and the Catholic Social Teaching received worldwide especially with its ecological extension in the environmental encyclical *Laudato Si'* [52]. Christian environmental ethics in the context of bioeconomy aims at a societal and scientific dialogue for a closer definition of the criteria and framework conditions required for a responsible bioeconomy strategy. The emphasis is on expanding the concept to include socio-cultural and political dimensions that give bioeconomic innovations a binding regulatory framework and a new direction.

The bioeconomy operationalizes the innovative side of sustainability by strategically tapping renewable resources and consistently avoiding waste. A bioeconomy understood in this way shapes technical, sociocultural and political transformations in order to integrate economic processes into ecological cycles and regeneration processes. It bundles the diverse innovation potentials of different actors and fields of action in relation to the ethical goals of a just and nature-compatible society. The bioeconomy aims at a combination of technical, social, economic and political intelligence. This is how progress will be measured in the future. Environmental ethics can make a significant contribution to orienting the debate about such a new bioeconomic concept of progress comprehensively towards the well-being of human beings and their ecological surroundings.

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