Strategic Transformation in Agriculture and Rural Space (STARS RAS)

Background Document
Building a Sustainable and Circular Bioeconomy in Croatia: Opportunities and Challenges

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The bioeconomy offers numerous opportunities to Croatia. From the promotion of resource efficiency for harnessing the food/non-food complementarity and creating value addition in traditional agrifood systems, to the contribution that bio-based products such as bio-based biodegradable plastic or bioenergy can have for addressing polluting problems in the country. Hence, if managed appropriately, the bioeconomy can create a wider variety of products, establish new markets and bring new income opportunities.

The Bioeconomy context

1. The bioeconomy is already happening and is making substantial contributions to society. According to the EU commission, the bioeconomy is the sustainable production of renewable biological resources and the conversion of these resources and waste streams into value added products in food, feed, bio-based and bioenergy products. The bioeconomy is considered a central element to the functioning and success of the EU economy. In 2015, it contributed an estimated €2.3 trillion turnover, €621 billion value addition and employed 18 million people, 8.2% of the EU's workforce. The principal contribution comes from the food, beverage and tobacco industry and agriculture, with 50% and 19% of the value generated, respectively. EU members have not yet realized the full potential of the bioeconomy. On the West, countries have made significant progress in the transition to the bioeconomy. On the East, countries are considered to lag behind despite their significant biomass potential.

2. Mainstreaming the bioeconomy into existing operational programs is paramount to address many of the sustainability challenges faced today. The EU updated its bioeconomy strategy in 2018 and set forth an ambitious Action Plan aiming to 1) scale up deployment of bio-based sectors, unlock investments and markets, 2) deploy local bioeconomies rapidly and 3) understand the ecological boundaries to establish a pathway for sustainable development. The new EU Bioeconomy Strategy Action Plan recognizes that exploiting synergies among EU and national instruments and funds, particularly the Common Agricultural Policy (CAP), the Common Fisheries Policy (CFP) as well as the cohesion policy and financial Instruments under the InvestEU Programme will be needed. In terms of the CAP, the bioeconomy can support the objectives of viable food production, sustainable management of natural resources, climate action and balanced territorial development. The European Agricultural Fund for Rural Development Program (EAFRDP) can significantly contribute by targeting actions that promote new or improved value chains, and associated infrastructure and facilities. In terms of the CFP, the bioeconomy, through the blue economy, can also support viable solutions to address pollution at sea, develop value added products and services from underused biomass and increase eco-friendly aquaculture production. The broad scope of the bioeconomy also cuts across multiple EU

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1 This document makes significant reference to the 2018 EU publication: A new bioeconomy strategy for a sustainable Europe. [Link](https://ec.europa.eu/research/bioeconomy/pdf/ec_bioeconomy_actions_2018.pdf#view=fit&pagemode=none)

2 Socioeconomic Indicators to Monitor the EU's Bioeconomy in Transition, T. Tonzo and R. M'Barek. European Commission, Joint Research Centre (JRC), Directorate for Sustainable Resources. Sustainability 2018, 10, 1745

initiatives such as the Circular Economy, the Energy Union, the strategy for plastics\(^4\), regional specialization, innovation and those related to environmental and climate change, as such coordination at the national level will be necessary to define inter-linkages and common actions across programs.

3. **A well-defined and sustainably managed bioeconomy can boost rural and coastal economies.** The majority of the bioeconomic activities are likely to be constraint close to biomass production source due to the higher cost of mobilization. This territorial nature of the bioeconomy will influence and transform the economies in rural/coastal area. Territorial and local development approaches will be critical to maximize the value of local resources, address challenges and opportunities of circular and sustainable agri-food systems and to bring together relevant actors across the territory including primary production and bio-based sectors. A review of four successful EU regional/subnational strategies (Bio-based Delta (WUR), Saxony-Anhalt (Ecologic), Scotland (EPRC), and the Veneto region (UCV)) incorporating bioeconomy actions showed that in all cases 1) the preparation process was led by regional level bodies with the participation of multiple stakeholder, 2) strategies were centered around the particular assets and strengths offered by the region, and 3) these were closely linked to EU requirements to ensure access to regional development funds for their implementation\(^5\).

4. **Bio-based solutions offer alternative pathways to modernize and make the agriculture, aquaculture and fishery more competitive.** The reliance of biomass and biological resources makes the agriculture, forestry, aquaculture and fishery central to the bioeconomy. As sustainability and circularity are at the heart of the EU bioeconomy strategy, the modernization in primary production systems to optimize biomass production in a sustainable manner is essential. Technological and innovation knowledge will be needed to develop ecological approaches and circularity in primary production and food system to enhance productivity and make efficient use of local natural resources. Innovation from industrial processes on the other hand will also be needed to help create opportunities to use by-products and co-products generated in existing agri-food value chain to deliver bio-based products alongside main products. These new market opportunities will not only enhance diversification of product outputs but also ensure competitiveness of the agri-food value chain. Significant commitment in funding for Research and Innovation in food, agriculture, rural development and bioeconomy is envisioned post 2020 to deal with the challenges of a sustainable and circular bioeconomy.

Bioeconomy Opportunities for Croatia

5. **In the void of a National Bioenergy Strategy, Croatia is already tapping into bioeconomy activities.** Croatia’s bioeconomy activities are largely focused on biomass production from crops followed by production of primary woody biomass and grassland systems (Figure 1). The biomass uses are concentrated mostly in the food and fiber

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\(^4\) European Strategy for Plastics in a Circular Economy adopted on January 2018

subsector. It is important to note that residues, by-products and co-products from crops and forestry are also been used for productive uses. Interestingly, uses of biomass are also supporting the production of bio-based products. These activities are more or less disconnected limiting their potential, and pointing towards an opportunity that a holistic integrated approach may offer. The essence of the bioeconomy is to bring together different economic sectors to develop integrated solutions to capitalize on multiple benefits: economic, sustainable and social. Designing a bioeconomy strategy and implementation plan is essential to align ongoing activities into a common and coherent framework to reap the benefits of a sustainable circular bioeconomy in Croatia.

Figure 1: Biomass Balance in Croatia - Full Trade


Source: DataM Joint Research Center, European Commission

6. **Croatia has potential to transition into a sustainable circular bioeconomy given its abundant land and marine natural resources.** The diverse agroecological conditions found throughout the country combined with the availability of clean water resources, both fresh and marine, are key assets to support a wide range of agriculture, maritime and aquaculture production systems. Efficient use of resources and value addition through product diversification are key to increasing the productivity of these systems. On the other hand, resource efficiency and value addition are central elements to a sustainable circular bioeconomy. Recognizing that the food & feed subsector are high value contributors to the bioeconomy today (Figure 2) indicates a huge potential for the bioeconomy in the country.

**Fig. 2: Representation of the a Circular Bioeconomy**

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7. **The Bioeconomy in the context of the Blue economy can open new opportunities for Croatia.** The newly revised EU Bioeconomy strategy identifies the untapped potential from marine and freshwater systems. It notes, however, that a better understanding of ocean resources and the marine environment is necessary to better assess and weigh opportunities and potential risks inherent to marine bioeconomic activities. From global trends, biowaste from fisheries and aquaculture is starting to be recognized by several sectors as a valuable feedstock. Likewise, as new technologies develop, market opportunities for higher value aquatic-derived biomaterials is growing. Innovation to explore waste management options in aquaculture systems and symbiotic (plant/fish) production systems are also emerging. How these global trends may impact the fisheries and aquaculture subsector in Croatia remains to be defined. As plastic pollution is one of the key challenges facing the sea, it will be important to assess the potential contribution that biodegradable plastics can have in addressing this problem in Croatia. Additional analysis to better understand the potential opportunities from management of by-products and co-products generated along national fisheries and aquaculture value chains is needed.

8. **Non-food biomass from waste and residues in the agrifood systems could be a potentially untapped resource.** Recent technology development has created the opportunity to use waste and residues from the agrifood supply chain to produce value added products. The potential reutilization of waste as industrial feedstock can have an important contribution to the transition towards the circular bioeconomy, support more integrated value chains and promote product diversification as a vehicle for competitiveness. Results from an assessment on potential availability of sustainable lignocellulosic materials from agricultural residues shows that between 2 and 3 million dried tons of materials could be available annually. The largest portion of biomass residues are from maize stover residues followed by straw from cereal production (Figure 3). Further analysis on the spatial distribution of these residues at NUTS3 level indicate that there is good distribution throughout the country (Figure 4).

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7 Note that the sustainable Availability indicates the biomasa that is available after discounting the ecological and soil needs for leaving residue in the field and current uses of biomass i.e. livestock bedding, energy production etc.

8 EU funded project entitled: Delivery of Sustainable supply of non-food biomass to support a “resources-efficient” Bioeconomy in Europe.
The University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture participated in the mapping of under-valued waste streams in agricultural production and supply chains in Europe. The project quantified co-products and by-products (AWCB) generated along animal, fruit, cereal and vegetable value chains based on statistical production data and technical coefficients. Consumption and population data are used to estimate the domestic food consumption (raw and cooked) per capita. This information is then used to estimate the food waste per capita based on waste to consumption coefficients, i.e. rotten beef to consumed beef ratio 0.11/0.20 kg/kg. The results show that, on average, around 10 million tons of waste are generated every year in Croatia (Figure 5). The largest AWCB is generated in the livestock sector in the production of manure. Further analysis is needed to assess the quantity and quality of AWCB that is available, not currently recycled or used, to have a more accurate information for future use. As this analysis is based on secondary information sources, it will be important to also ground the assessment, at least for the most relevant value chains in the country, to evaluate the

9 Information and data generate in the Agrocycle project can be accessed here: http://www.agrocycle.eu/
validity of these assumptions and/or to define local coefficients and parameters to monitor the production and use of these resources in the future. It will also be important to determine the spatial distribution of these resources to identify volumes available and potential market outlets that will make them viable feedstock for other industries. To this end, the Faculty of Mechanical Engineering and Naval Architecture has carried out additional work to ground the assessment and to define the spatial distribution of AWCB in Croatia, which will be an important input to this work.\textsuperscript{10}

**Figure 5: Waste, Co-Products and By-Products produced in Processing of Agricultural Products**

![](image)

Source: Own using data from Agrocycle EU Project

10. **In Croatia there is no concrete data on the quantities of food waste produced.** The above analysis on co-products and by-products estimates food losses and waste based on a farm to plate approach along specific value chains. This gives an indication of the food losses and waste generated in production and processing. At the household level, according to EU statistics, initial estimates from data on organic waste at landfill sites have been used indicating an amount of 380,000 tons per year (Croatian Agency for the Environment and Nature, CAEN, 2017). Food waste estimates associated with the distribution, retail and restaurant and food services industries are still missing. Understanding where and why food waste is generated along the value chain from production to processing to retail and consumption at the household level and by the food industry is key to identifying interventions. If prevention of food loss and waste is not viable, the organic material can become an important feedstock and a valuable resource for bio-based products. As the Ministry of Agriculture is currently responsible for the food waste prevention policy in the country, bringing food loss and waste management under the umbrella of a bioeconomy strategy could be a good way to address the issue as a part of the circular economy \textsuperscript{11}.

**Figure 6: Food Waste in EU Member countries in 2016 FUSIONS\textsuperscript{12}**

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\textsuperscript{10} Based on discussions with the Faculty of Mechanical Engineering and Naval Architecture, the work is currently undergoing review for publication. Once publication is available more details of the analysis can be access.


\textsuperscript{12} https://www.eu-fusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf
11. **The existing bio-based industry is a valuable foundation to innovate and open new market opportunities for biomass-based products.** Croatia has growing bio-based manufacturing and a traditional renewable energy industry. Over the past decade, the energy sector in Croatia has promoted the deployment of biomass-based energy production systems. Today, the energy sector is an important user of agricultural and forestry residues. Biomass energy production has largely been driven by “energy producers” rather than integrating production between agriculture and energy activities. As such, future opportunities for biomass to energy development should be considered through integrated agricultural-energy systems that actively involve farmers who will benefit from this alternative economic activity. One such opportunity is the growing demand for distributed energy generation that can use biomass/biogas to meet residential and industrial energy where business models with the active participation of farmers should be promoted. A national biomaterials industry is also evolving. Manufacturing of biodegradable plastics is one active area where both R&D work, i.e. Bio-mi Ltd, as well as actual manufacturing facilities, i.e. biodegradable films and bags from EcoCortec operate. The biodegradable plastics market in Croatia is a promising outlet that can trigger multiple benefits if developed appropriately. One important contribution is the potential reduction of plastic pollution in coastal areas. Developing this new market will require support beyond production to also develop the appropriate industry and infrastructure to recycle and reuse these materials to close the cycle. The Italian experience is an interesting case to explore to better understand its replicability in Croatia. Overall, research and innovation will be key to the development of alternative bio-based products (biopharmaceuticals/ biotextiles/ bioconstruction materials) in the short and medium term.

12. **The ongoing preparation of the post 2020 CAP Agricultural and Rural Development and Fisheries Strategic plans is an invaluable opportunity to mainstream the bioeconomy.** The post 2020 CAP operational program can support the bioeconomy by

Promoting biodegradable and compostable bags: In 2011 Italy introduced a first of its kind regulation banning the distribution of traditional plastic carrier bags allowing only the commercialization of biodegradable single use and long-life reusable bags. It created an opportunity to relaunch the green chemical industry through added value products, trigger construction of new plants for agricultural composting and treatment of biowaste, created new local integrated industrial opportunities.

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13 EcoCortec® specializes in manufacturing innovative, biodegradable, compostable films and offers customers complete converting, extruding and printing capabilities ([www.ecocortec.hr](http://www.ecocortec.hr)).
increasing the competitiveness of farming, ensuring the sustainable production of agricultural products and feedstocks for a bio-based industry, promote technology and innovation, supply and use of renewable sources of energy, waste, residues, and other non-food raw materials for the bioeconomy. Likewise, the opportunity exists to identify common areas of work between the bioeconomy and blue economy and how these could be embedded within the CFP operational program. While formulating its National Agriculture and Rural Development Strategy and a Multiannual Fisheries Development Plan, there is a clear opportunity for Croatia to incorporate bioeconomy considerations within its future programming.

**Challenges and opportunities to transition to a Sustainable Circular Bioeconomy**

13. **While the outlook for a sustainable and circular bioeconomy in Croatia is promising, lack of strategic integration and actions across sectors is missing.** The bioeconomy cuts across a number of sectors including agriculture, food, fisheries, forestry, energy, material industry etc. and cross-sectoral themes in sustainability and innovation, social and environmental policies, among others. Developing a cohesive national bioeconomy strategy requires the cooperation between the different sectors, coordination between diverse stakeholders and interlinkages across territories. Establishing a national framework that brings together the multiple actors across diverse sectors both in the public and private sectors is needed to guide the path for a sustainable bioeconomy.

14. **Working at the territorial level is necessary to make the bioeconomy work.** Natural resource assets vary across the territory and opportunities for developing the bioeconomy will also be diverse. Building an effective bio-economy requires territorial planning and a bottom up approach driven by local stakeholders to ensure ownership and long-term commitment. While working at the territorial level, spatial analysis can help guide the process to 1) map sustainable biomass potential and 2) identify promising regional biomass resources and value chains to guide the establishment of bioeconomy clusters. Spatial assessment will also be critical to determine logistical and supportive services to facilitate the utilization of biomass feedstock (i.e. agricultural and forest residues as well as organic wastes) more effectively.

15. **Optimizing production in primary sectors within sustainable boundaries.** From a biophysical perspective, the productivity levels for key crops in Croatia are low compared to their potential. To reduce the yield gap, biophysical mapping of crop potential and market analysis of potential demand are needed to prioritize interventions at the regional level and support effective local planning. Knowledge flows and digitization of information will be critical for modernization of agricultural production and post-harvest operations to realize a sustainable transformation of the agri-food sector. Within the bioeconomy context, there is an opportunity to generate more integrated and circular value chains that can help meet product diversification and bring new economic opportunities.
Next steps

16. Begin the process of preparation of a bioeconomy strategy, as an umbrella document to bring consistency and structure along a common vision and across multiple stakeholders and sectors. Recognition of the importance of the bioeconomy is already highlighted in the Croatian Smart and Specialization Strategy 2016-2020, where food and bioeconomy are identified as a thematic priority area. To support this process, the following could be pursued:

   a. Mapping of the various actors currently participating in the bioeconomy at the national level, identifying their current and potential activities related to a circular economy.
   b. Identify what activities are identified by different programs in relation to the bioeconomy and understand how these can be linked to deliver unified planning. This will also allow to identify potential gaps.
   c. Engage with regions/territories to raise awareness and assess their interest in the bioeconomy.
   d. Ensure that the perspective of the bioeconomy is integrated within the new CAP and CFP.
   e. Develop knowledge tools to assess the potential of the bioeconomy at the subnational level and guide preparation of regional bioeconomy plans.
   f. Within the Fisheries program, explore further how the bioeconomy and blue economy can be linked. Identify information/data available to assess the potential for blue bioeconomy in the country.
   g. Work with a region to pilot the preparation of a regional strategy to test the approach, tools and establish links across operational programs.
### Annex: Interim list of bioeconomy-related initiatives in Croatia

<table>
<thead>
<tr>
<th>Name</th>
<th>Focus</th>
<th>Focal points</th>
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<tbody>
<tr>
<td><strong>Horizon 2020 Research and knowledge and Research and Innovation</strong></td>
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<tr>
<td>BioEast Central and Eastern European initiative for knowledge-based agriculture, aquaculture and forestry in the bioeconomy.</td>
<td>Cooperation and development of knowledge base and Research area within the bioeconomy.</td>
<td>Ministry of Agriculture Other national technical bodies for specific Horizon 2020 project i.e. Energy Institute Hrvoje Požar</td>
</tr>
<tr>
<td>S2Biom Delivery of sustainable supply of non-food biomass to support a “resource-efficient” Bioeconomy in Europe Horizon 2020 funded</td>
<td>Support the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through knowledge, data and tools to help develop strategies and roadmaps.</td>
<td>SDEWES - International Centre for Sustainable Development of Energy, Water and Environment Systems</td>
</tr>
<tr>
<td>Agrocycle Horizone 2020 funded</td>
<td>Holistic approach to understand and address how to recycle and value agri-food waste.</td>
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<tr>
<td>PULPACTION</td>
<td>It will develop cellulose-based packaging solutions for the specific demands of the food and electronic packaging industries</td>
<td>MI-PLAST D.O.O</td>
</tr>
<tr>
<td>BIOBRIDGES</td>
<td>boost the marketability of bio-based products by establishing close cooperation and partnership between bio-based Industries, brand owners and consumers' representatives.</td>
<td>Particula Group Drustvo s Ogranicenom Odgovornocu Za Usluge</td>
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<tr>
<td>GRACE</td>
<td>demonstrate the techno-economic viability and environmental sustainability of miscanthus and hemp biomass-based value chains using marginal, contaminated and unused land</td>
<td>Sveučilište u Zagrebu Agronomski Fakultet</td>
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<tr>
<td>REFUCOAT</td>
<td>aims to develop fully-biodegradable packages for fresh food products</td>
<td>Mi-plast d.o.o. Za Proizvodnju Trgovinu I Pruzanje Usluga - Mi-plast LLC Manufacturing, Trading and Services (Croatia)</td>
</tr>
<tr>
<td><strong>Public policies/Initiatives</strong></td>
<td><strong>DanuBioValNet Cross-clustering partnership for boosting eco-innovation by developing a joint bio-based value-added network for the Danube Region</strong></td>
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<tr>
<td>Croatian Smart Specialization</td>
<td>Food and bioeconomy selected as a thematic priority area National Innovation Council co-chaired by Ministries in Economy and Science. Inter-ministerial working group where MoA leads Food and Bioeconomy.</td>
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<tr>
<td>Bioplastics Strategy TBC</td>
<td>The cluster of chemical plastics and rubber industries was established in 2013 Croatian Chamber of Economy- Industry sector</td>
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<tr>
<td>Industrial strategy</td>
<td>Identify strategic activities in the global value chain towards developing activities that create added value Ministry of Economy Entrepreneurship and Crafts</td>
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<tr>
<td>Innovation strategy</td>
<td>provide an efficient framework to strengthen the competitiveness of Croatian R&amp;D and economy in general through innovation and technological development Ministry of Economy</td>
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<tr>
<td>Strategy for Cluster Development</td>
<td>Ministry of Economy</td>
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