Smart SME's

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Mapping of actual state of play and needs

Synthesis report

Work package 2 (WP2), Action 2.4

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Prepared by BIOPRO Baden-Württemberg GmbH

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Abbreviations

GDP – Gross Domestic Product
IoT - Internet of Things[1]
R&D – Research and Development
SMEs – Small and medium-sized enterprises
VC – Value chain

[1] The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction; https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT.

Introduction

Digitalization is a very current topic in the Alpine region and gradually expanding into various fields. It is already widely used in business areas and becoming a part of everyday life, also in small and medium-sized enterprises (SMEs)[2]. This is due to various initiatives that help strengthen cooperation between businesses and research institutions. The integration of the digitalization is reflected in the development of distributed systems, smart factories, machine vision, blockchain technologies, digital services for education and public administration, development of digital competencies, promotion of innovation, and creation of new business models. The overall goal of the digitalization is to facilitate businesses of different sizes and to make easier their management and production processes by combining natural, financial and digital assets.

The most widespread renewable resources in the Alpine region, based on which commercial value chains can be built, are agricultural plants and wood. They serve as sources for natural fibers that are applied for further production up to end products sold on the market. Wood as biomass is mostly used in the energy sector (wood chips and pallets for heating) and pulp and paper industry. Moreover, efforts have been made to exploit abundance of the raw material in the polymer industry, namely for the use of biopolymer production from wood fibers.

The digital transformation in these two fields offers enormous opportunities and at the same time poses major challenges. It can make a significant contribution to process organization and division of labour. Enterprises, contractors and machinery rings can optimize production processes and make them more efficient. Stakeholders are able to tailor their services even more individually. The costs of inputs, products and services can be reduced by using digital systems.

Digital technologies in the plant and woody biomass production and processing are diverse. They range from technical hardware such as satellites or GPS, drones, robotics and sensors to software based on them, such as apps or online platforms. According to Bitkom[3], apps are the most frequently used software, followed by "intelligent software" (e.g. installed in agricultural machinery for driving assistance) and farm management platforms. In hardware, mainly high-tech agricultural machinery and automatic feeders are used. Robotics and drones are only used sporadically.

[2] The main factors determining an SME are staff headcount and either turnover or balance sheet total. Micro enterprise has less than 10 employees and turnover/balance sheet total less than €2 million; small enterprise has 11-50 employees and turnover/balance sheet total €2-10 million; medium-sized enterprise has 51-250 employees and turnover €10-50 million or balance sheet total €10-43 million. https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en
For the purposes of this research, farmers or any form of non-government business unit formed with an intention of making economic activity or producing raw materials for bio-based value chains shall be understood as SMEs and included in the report.
[3] https://www.bitkom.org/

The decisive factor for the success of innovative activities of a company is people who work there. That is why digitalization and transformation always begin with employees. It is also anticipated that SMEs, which are part of natural fiber-based value chains, have greater needs for digitalization.

Agriculture and wood production are characterized by the handling of large quantities of goods. The networking of digital technologies should improve logistics, thereby reducing traffic and CO2 emissions and environmental pollution in general. According to the German Federal Ministry of Food and Agriculture, digital applications increase the chances of safe storage and distribution of food even in times of crisis.

Objectives and methodology of the report

This report is devoted to the mapping of the actual state of play and needs with regard to the digitalization at small and medium-sized enterprises belonging to value chains with special focus on the use of natural fibers in the Alpine space. The report has the following goals:

- Mapping of knowledge available on digitalization relevant for SMEs, namely understanding the state-of-the-art of the digitalization "ecosystem" and its potentials;
- Learning the current status also of the digitalization level of SMEs, to which extent they already apply digitalization and whether they want to introduce new tools and approaches in their business activities;
- Revealing constrains, also from the education and training perspective, hampering the full digitalization as well as key factors enabling the capacity of digital adoption along the related VCs;
- Analyzing the existing remedies with a special focus on natural fiber-based VCs.

Target groups of this report are SMEs, business support organizations, regional and urban developers, policy makers, members of the Action Groups of the EU Strategy for the Alpine Region[4].

The report is based on the regional survey performed in a form of desk research by the project partners from Baden-Württemberg, Lower Austria, Slovenia and Trento. Specific examples of natural fiber-based value chains with different application fields were chosen and analyzed. The analysis included a holistic circular bioeconomy approach and took into consideration value chains starting from cultivated natural fibers as well as recycled fibers from biological waste in previously selected industrial application. The empirical part was conducted in a questionnaire form for SMEs working with natural fibers. The methodology as well as the final analysis were elaborated by the lead of the work package, BIOPRO Baden-Württemberg.

[4] https://www.alpine-region.eu/action-groups

Important economic facts

Baden-Württemberg (BW) is the biggest and the most populated region participating in the project "Smart SME´s". It is located in the southwest of Germany. Baden-Württemberg is also the most innovative state not only in the country but in the whole EU (with the innovation index 82)[5] and has the highest number of patents per capita in Europe[6]. Its GDP is also 8-27 times higher in comparison with the other selected regions. The strongest economic sectors are automotive, chemical and electronic industries; nevertheless, Baden-Württemberg is quite successful in commercialisation of bio-based industry inventions.

Lower Austria is one of the nine federal states of Austria and located in the northeast of the country. It is surrounded by high-growth markets in Central and Eastern Europe. Geographically, it encloses Vienna, which in juridical terms is not part of the region, but has a substantial influence on its economy and thus stimulates an investment friendly climate. There is no real economic sectorial focus. Lower Austria has a relatively heterogeneous structure in terms of business sectors; many different branches are active there, such as green building, food, plastics, mechatronics sectors, etc.[7]

The economy of Slovenia is characterized by innovation, work morale and loyalty to businesses. High level of digitalization resp. high ranking on various indexes and received titles confirm that Slovenia is a modern and digitalized country focused on the sustainable development. Considering that Slovenia is the second most forested European country, it is understandable that wood processing and furniture industries are among the strongest ones. The wood processing industry has been experiencing a new upswing in recent years, mainly because wood remains a key material of the low carbon society.

Trento, located in the north of Italy, is the smallest region in terms of the territory, population and GDP among the project partners. Its most important economic sector is the service industry[8] with about 169.000[9] working places (1/3 of the region´s population) and 12.800 million euro[10] of added value.

The main fundamental economic figures of the selected regions are presented in table 1.

[5] https://www.statistik-bw.de/Presse/Pressemitteilungen/2018291
[6] https://www.statistik-bw.de/Presse/Pressemitteilungen/2016358
[7] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/lower-austria
[8] http://www.statweb.provincia.tn.it/PubblicazioniHTML/Annuari%20e%20altre%20pubblicazioni%20di%20carattere%20generale/Conoscere%20il%20Trentino/Conoscere%20il%20Trentino%202018/capitolo06/t06_006.html
[9] http://www.statweb.provincia.tn.it/PubblicazioniHTML/Annuari%20e%20altre%20pubblicazioni%20di%20carattere%20generale/Conoscere%20il%20Trentino/Conoscere%20il%20Trentino%202018/capitolo07/t07_001.html
[10] http://www.statweb.provincia.tn.it/PubblicazioniHTML/Annuari%20e%20altre%20pubblicazioni%20di%20carattere%20generale/Conoscere%20il%20Trentino/Conoscere%20il%20Trentino%202018/capitolo06/t06_003.html

Parameter	Baden-Württemberg[11,12,13]	Lower Austria[14,15]	Slovenia[16,17,18]	Trento[19,20]
Population, number of people (2018)	11.069.533	1.670.688	2.094.060	541.098
GDP	511,4 billion euro (2018)	61 billion euro (2018)	46,6 billion euro (2018)	19,5 billion euro (2017)
Territory of the region/country	35.751 km^2	19.186 km^2	20.273 km^2	6.207 km^2
Utilized agricultural area in % to the total area	40%	56,6%	23,75%	41%
Forest area in % to the total area	38%	40%	58,07%	53,4%
Percentage of SMEs of the whole economic sector	99,3%	99,8%	99,8%	89%
Percentage of SMEs in the fiber-based sectors	n/a	n/a	85%[21]	n/a
Industries in which fiber-based sectors can be involved	• housing and construction • furniture • food supplements • cosmetics • pharmaceuticals • animal feed • pulp and paper	• textiles • farming • production of biomass and fibers from it • plastics • taple fibers, filaments, blended fabrics • paper industry • cellulose	• housing and construction • furniture • food supplements • cosmetics • pharmaceuticals • animal feed, new materials	• agrifood and waste • wood for building • biotechnology and crop protection products • livestock bioenergy

Table 1. Fundamental economic figures

[11] https://www.statistik-bw.de/GesamtwBranchen/VGR/VW_wirtschaftskraft.jsp
[12] https://www.landwirtschaft-bw.info/pb/,Lde/3650826_3651462_5405915_5428928
[13] https://www.statistik-bw.de/GesamtwBranchen/UnternehmBetriebe/040230xx.tab?R=LA
[14] https://en.wikipedia.org/wiki/Lower_Austria
[15] https://www.ecoplus.at/media/6518/unternehmerland_noe_engl_web.pdf, p. 9
[16] https://pxweb.stat.si/SiStatDb/pxweb/sl/30_Okolje/30_Okolje__15_kmetijstvo_ribistvo__03_kmetijska_gospod__01_15165_zemljisca/1516501S.px/table/tableViewLayout2/
[17] IPMMP – EPF UM_ Slovenski podjetniški observatorij; po podatkih AJPES, 2018a (za leta 2013–2017) (2018)
[18] https://en.wikipedia.org/wiki/List_of_Austrian_states_by_GDP
[19] http://www.statweb.provincia.tn.it/annuario/
[20] ISPAT - Statistic Institution of Trento Province: Professional agriculture in Trento. (2014).
[21] Estimation based on the number of members (SMEs) of Strategic research and innovation partnership for Sustainable food production, Circular Economy and Wood Industry Cluster Slovenia

What especially interesting in the selected regions is that SMEs prevail strongly in the economy, reaching more than 99% in Baden-Württemberg, Lower Austria and Slovenia. Nevertheless, they still do not "rule" the economy. Strong industrial actors make the major contribution to the state´s economy.

More than a half of the territory is covered with forest in Slovenia and Trento, therefore natural fibres come mainly from the forestry and wood processing sectors. In Lower Austria, the main source of the bio-based fibers is, vice versa, the agricultural industry. In Baden-Württemberg, natural fibers come almost equally from the wood and agriculture.

Value chain mapping

In order to perform the value chain mapping, each region chose an agricultural plant, that is economically important and used to the largest extent in fiber-based value chains. Based on the available data about respective stakeholders, which work with the plant as a feedstock or consume products made of it, there were developed two value chains: 1) starting from cultivation and 2) starting from recycling from biological waste in previously selected industrial applications. Two regions, Slovenia and Trento, developed also value chains based of the woody biomass.

Fibre-based value chains in agriculture in Baden-Württemberg (maize)

For the fiber-based agricultural value chain in Baden-Württemberg, maize was selected, as it is the second most important field crop in the region, after wheat. In 2019, 192.800 ha of maize were cultivated. Silage maize took up the largest part of the cultivated area, 136.200 ha. 56.600 ha were covered with grain maize. A year earlier, in 2018, 8.830 kg/ha of grain maize and 43.780 kg/ha of silage maize were harvested[22]. In case of the latter, the entire plant is collected usually when it is still a bit green. After harvesting, the plant is chopped into small pieces and preserved as silage in the airtight silos. The silage can be fed to cattle all year round or used in biogas plants. Grain maize is ready for harvest when the plant is completely ripe and dry. Only corn grains are harvested; the rest of the plant remains in the field and thus supports the formation of humus. Corn grains contain a lot of energy and are eaten by pigs and poultry. In addition to its importance as a supplier of high-quality food and feed, corn is also increasingly used as an important natural raw material for further industrial processing in the technical-industrial sector, for example, in the starch industry. Corn starch is applied for producing plastics, paper and cardboard, adhesives, packaging and insulating materials, pharmaceuticals, cosmetics, fuels, abrasives and polishing materials. Another product that can be obtained from corn is corn germ oil rich in fatty acids and vitamin E and extracted from the germ of the corn kernel[23]. Furthermore, semolina and alcohol can be produced from the corn kernel. The corn cob can also be used effectively. Its areas of application are, for example, as fuels, abrasives, sound carriers, floor coverings, hardboard, animal litter, pharmaceutical products, polishing agents, oil binding agents, winter litter or insulation material. [24,25,26]

Figure 1 depicts a value chain starting with the cultivation of maize plant up to manifold products through all production and market phases.

[22] ttps://www.maiskomitee.de/web/upload/pdf/statistik/dateien_pdf/Maisanbauflaechen_D_je_BL_in_ha_2018-2019_vorlaeufig_20190802.pdf
[23] https://www.vgms.de/staerkeindustrie/lebensmittel/weitere-naehrstoffe/maiskeimoel/
[24] https://www.maiskomitee.de/Verwertung/Industrie
[25] http://maisfakten.de/story/Mais%20zur%20industriellen%20Nutzung%20-%20eine%20umweltschonende%20Alternative%3f
[26] https://www.vdgs.org/sparten/maisstaerke

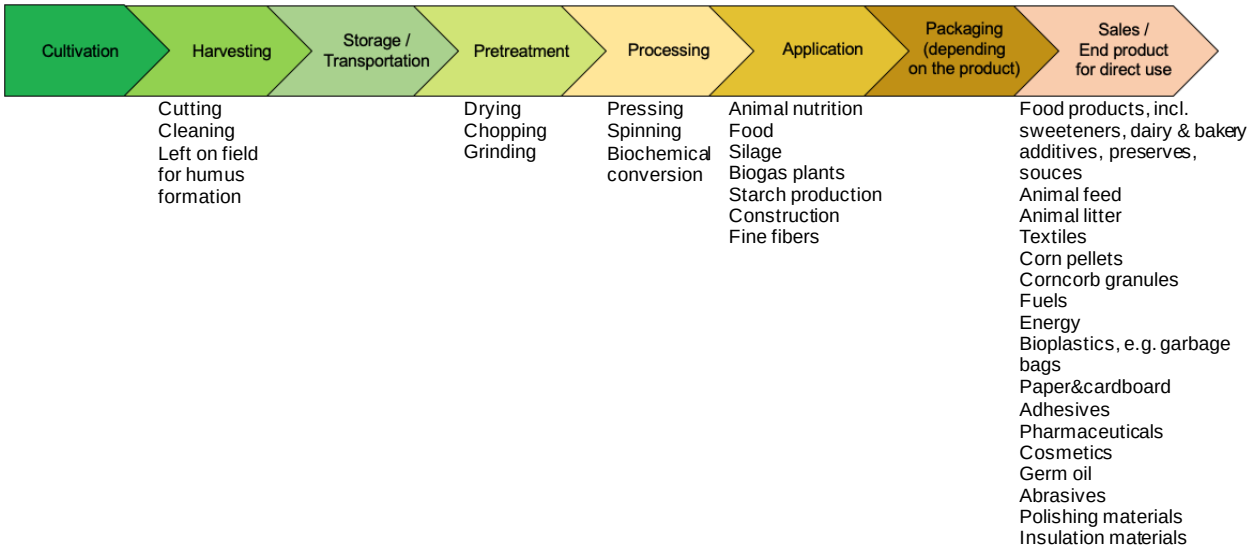

Figure 1. Maize value chain starting from plant cultivation (Baden-Württemberg, Germany)[27]

A value chain based on the recycling of maize as biological waste as well as recycling of products made of the plant in Baden-Württemberg is presented in figure 2.

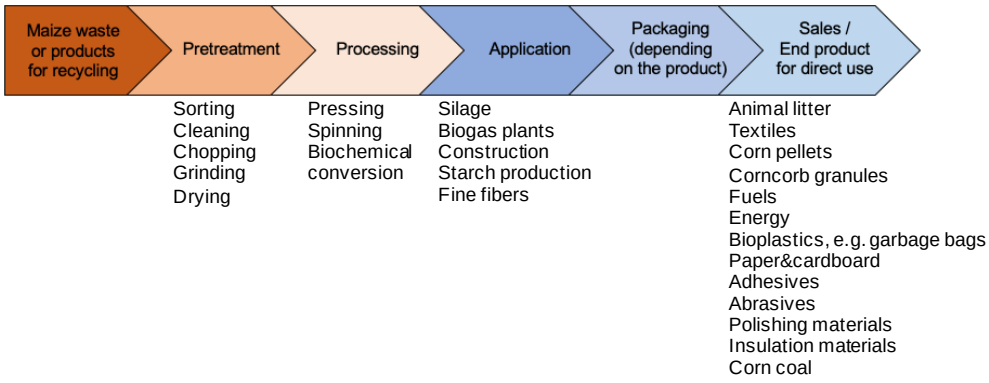

Figure 2. Maize value chain starting from recycling (Baden-Württemberg, Germany)[28]

One of the most sustainable applications of the corn cob existing in Baden-Württemberg is using it as a corn coal, for example, as an adequate alternative to charcoal for barbecue. The idea was invented by the start-up Kolbenglut.[29]

[27] Self-developed by BIOPRO Baden-Württemberg. (2019).
[28] Self-developed by BIOPRO Baden-Württemberg. (2019).
[29] https://www.kolbenglut.com/#start

There are SMEs in Baden-Württemberg which can be assigned to one or another step of these value chains. Nevertheless, agriculture play only a minor role in matters of the state´s GDP, with a decreasing tendency. Its current contribution is less than 0,5% of the GDP, which equals only a half of the economic contribution compared to 1991.[30] Thus, it is still not easier for small maize growers to survive; medium-sized companies feel better on the market. However, the most maize producers in Baden-Württemberg are branches of the big market players, Germany and Europe wide. In terms of processing of natural fibres, the lack of knowledge transfer between research and academia, where usually new technologies are born, does not let SMEs benefit fully from technological achievements, especially newly elaborated digitalization tools. Thanks to the solid innovation status of Baden-Württemberg and the existing support programs of the state government, there is a high potential for SMEs to develop new technologies for processing natural fibres. As mentioned above, there is a range of manifold applications of maize fibres - in agriculture, food, cosmetics and chemical industries, biotechnology, building, and many more.

Fibre-based value chains in agriculture in Lower Austria (hemp)

Hemp is one of the most important agricultural plants in Lower Austria. It is usually planted in April; leaves are harvested in June and corns in September. Yields are amount 600-1000 kg/ha; produced later on fibers are counted with 3-4 t/ha. Hemp allowed for consumption is applied for production of food and supplements (snacks, muesli, cookies, chocolate, tea, oil). Hemp protein powder is used as a food additive. Moreover, hemp is applied in husbandry, e.g. animal feeding, and veterinary products. Fibers are also interesting for producers of paper, textiles, thermal insulation materials, plastic composites for cars, etc.

Figure 3 depicts a value chain starting with the cultivation of hemp plants up to products through several production phases.

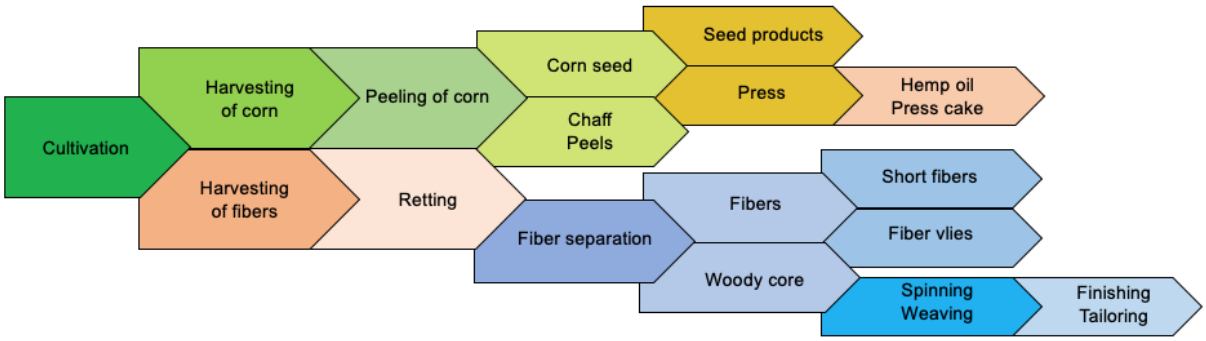

Figure 3. Hemp value chain starting from cultivation (Lower Austria)[31]

[30] Betzholz, T., Büringer, H., Hartmann, A., Schmauz, S., Schmidt, K., Seitz, R., Thalheimer, F. & Weißenberger, D. (2014). Landwirtschaft und Umwelt in Baden-Württemberg. Reihe Statistische Analysen, 03/2014. Statistisches Landesamt Baden- Württemberg, Stuttgart.
[31] Self-developed by the Institute for Industrial Ecology, St. Pölten, Lower Austria. (2019).

The focus of the activities within the value chain is on the use of hemp with its manifold possibilities. The added value is to be achieved from the multitude of individual products together. The value chain is thus not linearly aligned to one (or several, parallel) product(s), but to the use of the individual ingredients in the sense of the whole plant use. Recycling of hemp is not carried out in Lower Austria since it is simply burnt.

The hemp value chain in Lower Austria demonstrates significant gaps, especially in the steps of pretreatment and processing (e.g. only peeling or retting), which leads to the conclusion that there are no market players (e.g. SMEs) that could be theoretically included in the value chain. Also, the range of different producers is minor, they are poorly represented. The gaps can be partly explained by the fact that harvesting and processing of hemp is not precisely regulated (in the majority of the EU countries even forbidden). This means that policy actions have to be taken, best of all in close cooperation with researches and producers.

Fibre-based value chains in Slovenia

Wood sector

The most important natural renewable source or biomass in Slovenia is wood and its by-products. In 2018, the export of unprocessed wood achieved 2,6 million m^3, and the export of timber products amounted to 51% of the total amount of timber products manufactured. In the same year, timber production in state forests has increased by 32%.[32] Wood as biomass is mostly used in the energy sector (wood chips and pallets for heating) and the pulp and paper industry. In the past, there were efforts to exploit abundance of the raw material in the polymer industry, namely for the use of biopolymer production from wood fibers. In figure 4, wood serves as feedstock for an eco-construction value chain.[33]

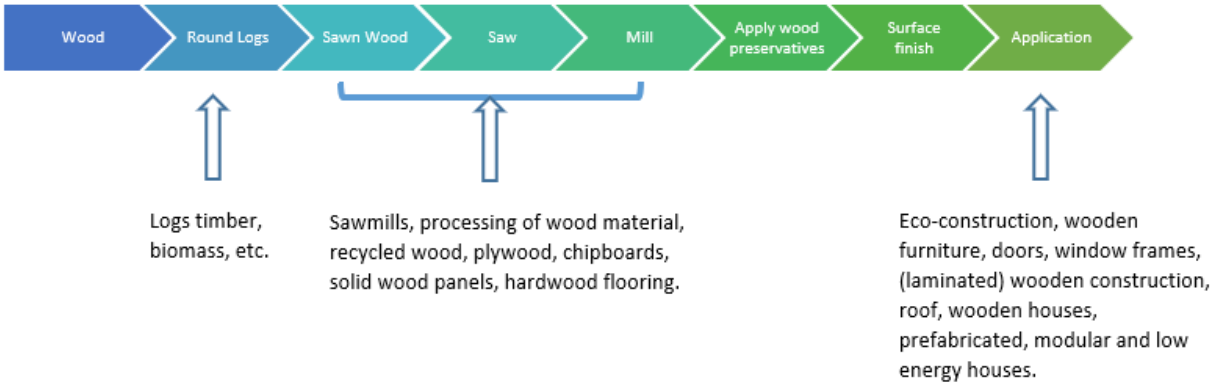

Figure 4. Eco-construction value chain starting from wood as feedstock (Slovenia)[34]

[32] WoodChainManager, http://wcm.gozdis.si/strokovni-prispevki/trg-gozdnih-lesnih-sortimentov-v-sloveniji-v-2018.
[33] Small business act, http://mgrt.arhiv-spletisc.gov.si/si/delovna_podrocja/podjetnistvo/akt_eu_za_mala_podjetja_small_business_act/.
[34] Self-developed by UM-FERI and Anteja ECG, Slovenia. (2019).

For the eco-construction value chain, two entities cover all six segments from wood harvesting and round log handling (wood processing) to surface finishing, advance wood composite manufacturing, and end-products (houses, furniture) (semi- and final products). Throughout this study, a list of SMEs participating in each eco-construction value chain component was identified (see Slovenia country report, p. 69, Annex 3), which represent many cluster support and other initiatives. Despite natural limitations caused by forest compositions, the wood harvesting and timber hauling processes are carried out by using adapted modern machinery by most entities, while taking environmental protection into account. After the initial processing of harvested wood, the resulting timber logs and biomass are used as a resource material for further processing. According to the report published by the Slovenian Forestry Institute, in 2018 the production of logs in state forests was 36% from the total amount of logs produced, while the rest of the production of logs derives from private or local community forests. In addition, there was an increase in selling wood for pulp and round industrial timber production, but also a decrease in the number of logs and firewood sold.[35]

According to the 2016 data, only 5% of waste wood is recycled in Slovenia, while 62% of that wood is intended for energy production, or simply burnt. Compared to other types of waste in Slovenia, wood waste represents only 2% or approximately 148.000 tones of all waste.[36] Value chain starting from the recycled wood waste in depicted in figure 5.

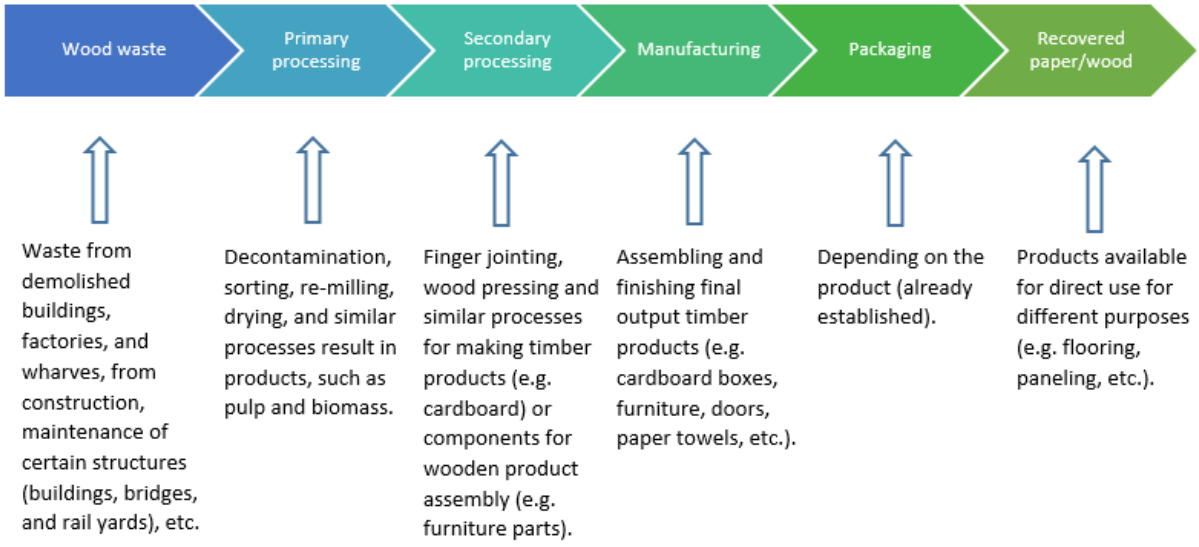

Figure 5. Wood value chain starting from recycling (Slovenia)[37]

[35] WoodChainManager, http://wcm.gozdis.si/strokovni-prispevki/trg-gozdnih-lesnih-sortimentov-v-sloveniji-v-2018.
[36] https://www.stat.si/StatWeb/en/News/Index/7067
[37] Self-developed by UM-FERI and Anteja ECG, Slovenia. (2019).

Most of the wood intended for recycling is obtained from factories, wharves, or from construction and demolition, or maintenance of buildings and structures, such as bridges and railway tracks.[38] A few years ago, the majority of this waste material went to landfills, but today the goal is to maximize the percentage of recycling. The main purpose of recycling is to turn used wood residues back into something useful. The final product of the recycling chain is recovered wood, in a form of products intended for various usage (from flooring, paneling to furnishing and home decoration). Less quality wood is typically used for the energy production.[39] The list of the companies that are part of the wood recycling value chain is presented in the Slovenia country report (p. 71, Annex 3).

Agriculture

For the second fiber-based value chain, apples and algae plant were selected. Slovenia possesses the knowledge, necessary raw materials and technologies as well as natural resources for that. Apples are among fruits that are produced at most; in 2018 the harvest amounted 86.587 tones[40]. In the production of apple juice, there are many residues (apple pomace) that can be used for distilling spirits, or they can be composted or converted into biogas. In processing of juices, pulp, frozen products, etc., water is also used for washing fruits. This industrial wastewater can be further used for algae cultivation. This is a natural raw material that for cultivation does not require agricultural land, but one of the preconditions for algae installations is the location with a lot of sun or light, and that is why Slovenia is more appropriate.

The biotechnology of microalgae has gained considerable importance in the recent decades. Applications range from the production of food supplements, animal feed and live feed in aquaculture to valuable products for pharmaceutical and ecological applications. Also, exploitation of microalgae for bioenergy generation or combined applications for biofuels and CO2 mitigation, by which CO2 is captured and sequestered, is under research. For most of the applications, the market is still developing, and the biotechnological use of microalgae will extend to new areas. Considering the enormous biodiversity of microalgae and developments in genetic engineering, this group of organisms represents one of the most promising sources for new products and applications.[41] In this field, some "newcomer" SMEs in Slovenia have found their market niche. Value chains for recycling of apple waste are presented in figures 6 and 7. It is anticipated that the companies in this value chain have greater needs and opportunities for digitalization[42].

[38] Muthu, S. S. (2015). Environmental Implications of Recycling and Recycled Products.
[39] https://www.manwithoutcountry.com/the-importance-of-recycling-wood-waste/
[40] Statistical office of Republic of Slovenia
[41] https://algen.eu/node/95
[42] http://mgrt.arhiv-spletisc.gov.si/si/delovna_podrocja/podjetnistvo/akt_eu_za_mala_podjetja_small_business_act/

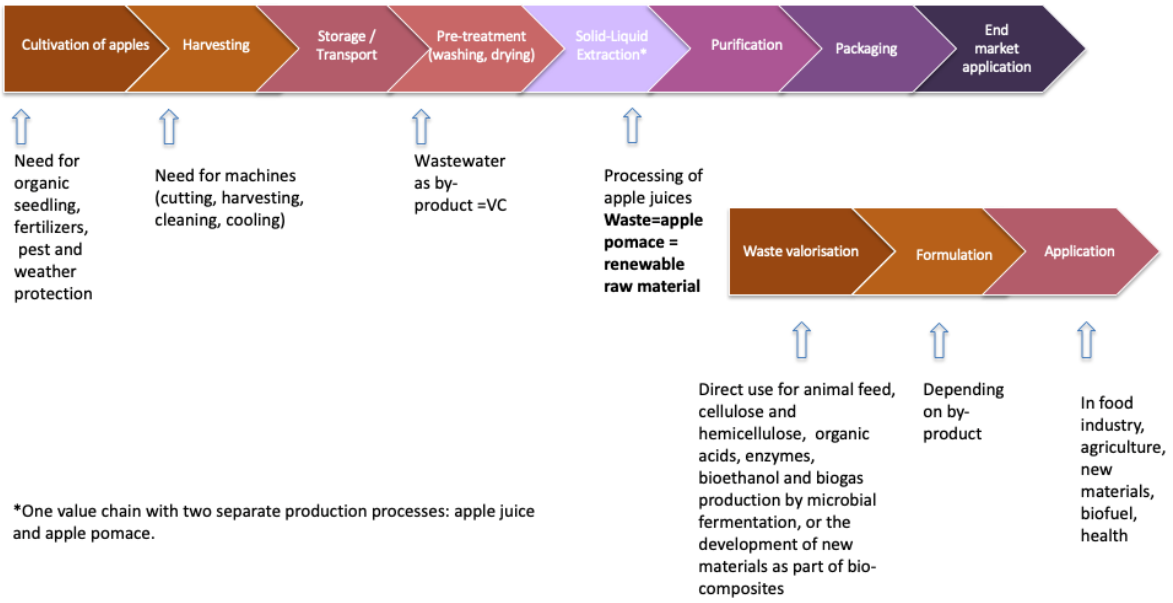

Figure 6. Value chain starting from recycling of apple waste (Slovenia)[43]

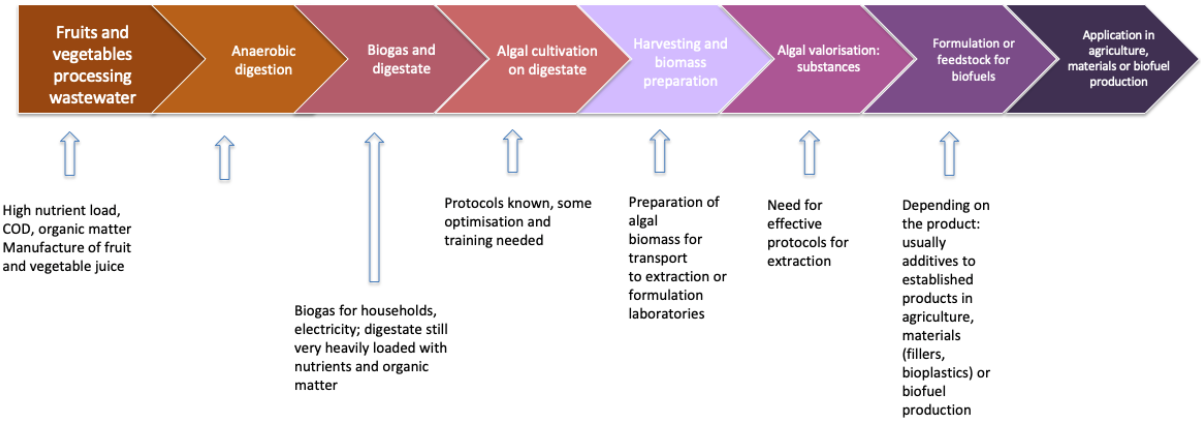

Figure 7. Value chain for algae production from wastewater (Slovenia)[44]

Examples of SMEs that produce food for algae as by-product are beverage producers, breweries, dairies, vegetable producers. For the algae growers, a specialized company can be used and eventually the ponds are or can be owned by companies themselves. Users of algae and algae raw materials (lipids, proteins, pigments) could be the food processing industry, juice producers, salt pans (include spirulina in their products), as well as dairy products, pet products, livestock products. The lists of the Slovenian companies that are part in the value chains for algae produced from recycling of biological waste and wastewater are presented in the Slovenia country report (pp. 74-75, Annex 3).

[43] Self-developed by UM-FERI and Anteja ECG, Slovenia. (2019).
[44] Self-developed by UM-FERI and Anteja ECG, Slovenia. (2019).

Fibre-based value chains in Trento

Agriculture

In Trento, it is difficult to find natural fibre production that includes the whole value chain, starting from harvesting up to industrial application and has also outcomes on the market. There is though one observable value chain that concerns the textile industry.

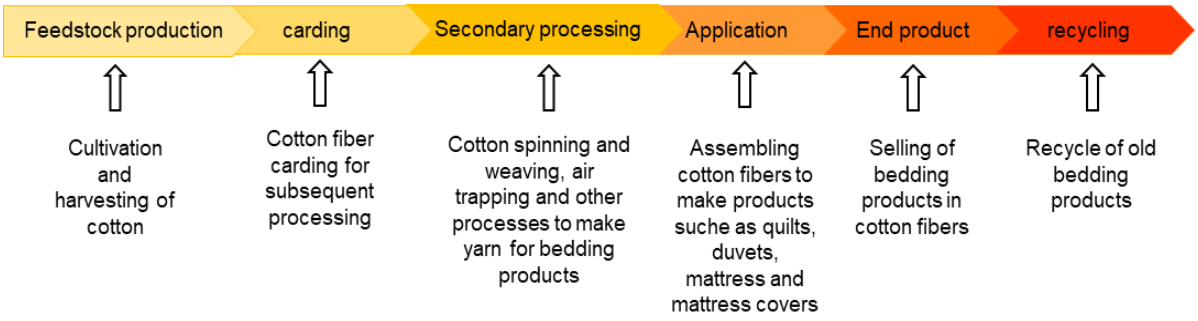

Figure 8. Value chain for textile industry (Trento, Italy)[45]

There are several companies using and processing cotton fibre as a textile fibre to fabricate quilts, duvets, mattresses and mattress covers. They also use other natural fibres as wool, tencel or inflò that comes from corn sugar. However, these companies do not produce natural fibres, but most likely take them from other enterprises outside Trento. There are sellers of these products, incl. online shops. Besides, at least one company in the region tries to understand if recycling old mattresses can have a positive impact on the market. All of them are micro-sized enterprises with a number of employees up to 10.

Furthermore, there is a strong potential in Trento in applying of waste coming from grapes or apples that can be used as a recycled feedstock (like in Slovenia). Grapes are mainly addressed in winemaking industry, with a solid waste, which can be estimated about 30% of the material used (stems, skins, seeds). The average grape production in the Trento region is about 1.200.000 quintals. From 100 kilos of fresh grape, there can be obtained almost 80 kg of must, up to 10 kg of skin, 3 or 4 kg of grape seeds and almost 4 kg of stem. About half of the waste from vineries is sent to distilleries, some is used as biomass, some as fertilisers and a small part is applied in the cosmetic industry. Apple cultivation is the second important agricultural sector in Trento. The lower quality fruit production is addressed to juice industry, vinegar industry and zootechnical sector. The value chain based on the recycling of waste from apple and grapes production is shown in figure 9.

[45] Self-developed by Hub Innovatione Trentino – Fondazione and Autonomous Province of Trento – Department for Economic Development, Research and Labour. (2019).

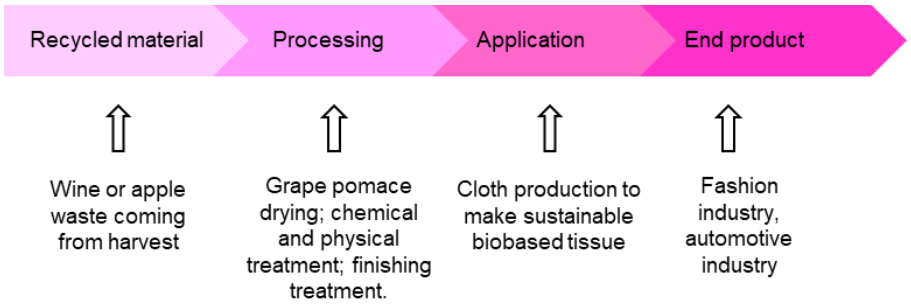

Figure 9. Value chain based on the recycling of waste from apple and grapes production (Trento, Italy)[46]

The value chain for using fruit waste to produce eco-fabrics for fashion or automotive industry is simplified and not depicted in very details, which does not let make a conclusion how completed it is in terms of the availability of respective companies, e.g. for pre-treatment, storage, transportation, packaging, etc. There are though 155 farms and 15 cooperatives in Trento that potentially produce winery waste. However, there is lack of information whether companies deal with the processing and application of eco-fabrics, namely those that work with eco-leather and might use eco-fabrics coming from wine or apples in their manufacturing.

Wood sector

Trento promotes the use of wood for sustainable construction sector and energy efficiency. Fibre-based materials in the construction sector represent a valid alternative to classic materials used in the industry, for example for insulating panels.

Spruce represents in Trento 60% of wood, the majority of which is normally sold. The value chain in figure 10 considers spruce as a feedstock that is processed into wood wool. This natural fibre has breathable features and meets the requirements of sustainable architecture. It is then used to make acoustic insulant panels, e.g. MDF (medium-density fibreboard panels). In Italy, around 90% of wood waste is turned into particle board or MDF panel board. It seems though that in Trento there are no enterprises processing wood biomass to make wood wool composite, but there are few companies that apply this composite in panels. These companies could sell panels, e.g. MDF panels, to other enterprises in the building industry and to the ones manufacturing doors and windows. Alternatively, they could use them, as end product, because there may be companies working in property renovation. Closest producers of wood wool and fibre boards are located in Veneto and South Tyrol. Wood for panels come both from Trento alpine forests and from abroad, e.g. Slovenia.

[46] Self-developed by Hub Innovatione Trentino – Fondazione and Autonomous Province of Trento – Department for Economic Development, Research and Labour. (2019).

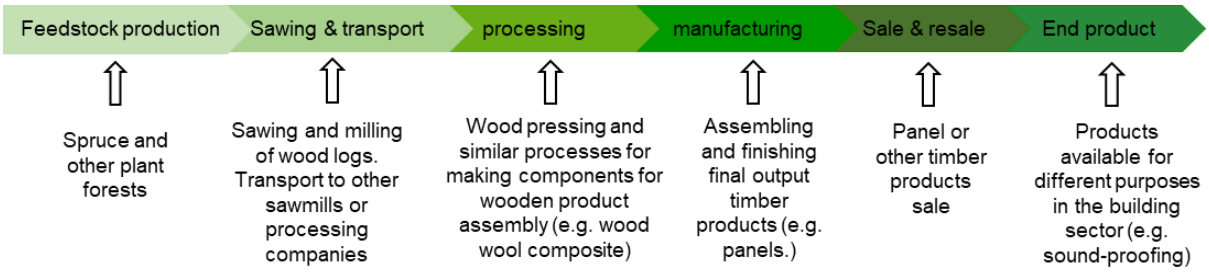

Figure 10. Value chain based on spruce processed into wood wool (Trento, Italy)[47]

The value chain in figure 11 uses as a recycled material wood fibre coming mostly from sawing waste or from forestry conservation works.

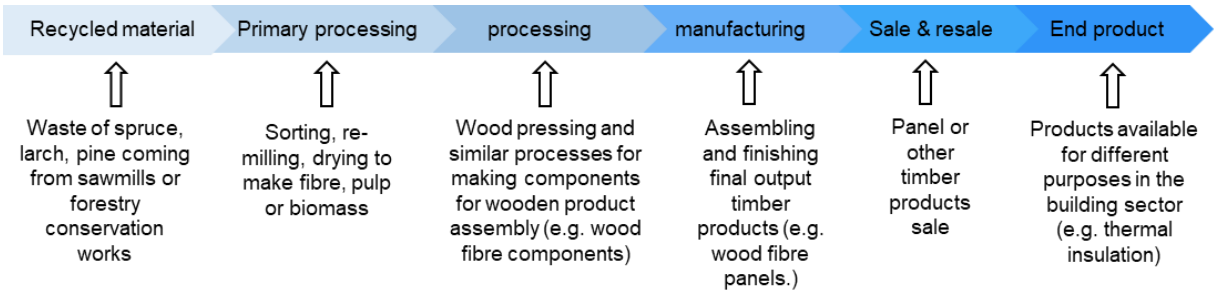

Figure 11. Value chain based on wood fibre from sawing waste or forestry conservation works (Trento, Italy)[48]

In Trento, 76% of the forest area is in the public property, while 24% is private. Main plants used for wood fibre are spruce, larch and pine. There are around 50 sawmills in Trento, the waste from which production can be ideally used for making wood fibre components. Companies process the wood fibre components to make complete panels that are then used as a building material for thermal insulation, roof insulation and pavements soundproofing.

[47] Self-developed by Hub Innovatione Trentino – Fondazione and Autonomous Province of Trento – Department for Economic Development, Research and Labour. (2019).
[48] Self-developed by Hub Innovatione Trentino – Fondazione and Autonomous Province of Trento – Department for Economic Development, Research and Labour. (2019).

Digitalization knowledge ecosystem

Digitalization is a present topic in the selected Alpine regions and the access to such knowledge is available to SMEs in various ways. However, in spite of the fact that SMEs account for more than 85% of all companies, and in some regions exceed even 99%, their input in the entire digitalization expenditure is still low. For instance, in Baden-Württemberg this indicator amounts only 11%[49].

In order to support SMEs, the Ministry of Economic Affairs, Employment and Housing of Baden-Württemberg (WM) has launched the initiative "Industry 4.0"[50]. Furthermore, several cross-industry projects have already been launched within the framework of the initiative "Wirtschaft 4.0" [51]: digital hubs, digitalization premium, innovation voucher "High-Tech Digital"[52], and the contest of ideas for knowledge and technology transfer.

The Digital Innovation Center (DIZ) [53] bundles the existing resources and know-how of stakeholders and realizes the basic idea of the digital transformation through comprehensive networking. The goal is to support SMEs in their efforts for digitalization in a sustainable manner and thus to advance the digital transformation in the state holistically.

The regional Digital Hubs[54] are unique crystallization points for digital innovations in Baden-Württemberg where the most diverse competencies, disciplines, ideas, technologies and creativity come together. They are regional contact points for SMEs of all industries for questions regarding digitalization. There, companies can also test new ideas for digital projects in the experimental rooms.

Based on the excellent scientific expertise, the project "Business Innovation Engineering Center" (BIEC) [55] provides SMEs with the knowledge on innovation at the services and business level as well as at the organizational and management level, e.g. with smart products, digital and data-driven business models.

The interdisciplinary digitalization strategy of Baden-Württemberg "digital@bw"[56], which was presented in 2017, contains a large number of innovative projects and measures. The state government provides around 1 billion euros for their implementation by 2021. The strategy is focused on the population of Baden-Württemberg and demonstrates concrete benefits of modern digitalization technologies to people with the help of innovation projects and pilot schemes. Provision of excellent training for junior staff and support of local authorities in

[49] https://www.baden-wuerttemberg.de/fileadmin/redaktion/dateien/PDF/200204_Innovationsstrategie_BW_Fortschreibung_2020.pdf, p. 51.
[50] https://wm.baden-wuerttemberg.de/de/innovation/schluesseltechnologien/industrie-40/allianz-industrie-40-bw/
[51] https://wm.baden-wuerttemberg.de/de/innovation/initiative-wirtschaft-40/
[52] https://wm.baden-wuerttemberg.de/de/innovation/innovationsgutscheine/innovationsgutschein-hightech-digital/
[53] https://www.diz-bw.de/
[54] https://www.digital-bw.de/-/regionale-digital-hubs
[55] https://biec.iao.fraunhofer.de/de/ueber-uns.html
[56] https://www.digital-bw.de/-/alles-beim-neuen

shaping central policy areas, such as mobility, education or health in urban and rural areas in a future-oriented and sustainable manner, are among main goals of the strategy.[57]

In Lower Austria, digitalization has also reached SMEs to the same extent as bigger companies; SMEs do not see this process as a threat but as a chance for future business[58]. The region already features a diverse and broad ecosystem to foster innovation and digitalization. For example, the House of Digitization[59] is the lighthouse project of the Lower Austrian digitalization strategy, which addresses the needs for digitalization of SMEs. It is a platform that offers companies and researchers the connection of their interests, digital skills, expertise, and it also provides knowledge and networks customized to the local setting. As such the House of Digitalization is the center for technological change in education, science, business and administration in Lower Austria. Another project under the ecoplus`s supervision is the Digital Innovation Hub[60]. It offers a comprehensive three-year service program to increase the transformation capacity and transformation speed of SMEs in Eastern Austria (Lower Austria, Upper Austria, Burgenland and Vienna) towards digital innovations.

The digitalization ecosystem in Lower Austria is also complemented by a number of incubators and investors, which provide start-ups and other businesses with advice, support and financial means to develop new ideas or to strengthen the digitalization in the region. Lower Austria has also introduced its Digitalization Strategy, which includes three main goals: securing and creating new jobs, strengthening rural regions and improving life quality[61].

In Slovenia, aspects of the digitalization are entering different business domains and becoming a part of everyday work, also of SMEs. However, the degree of digital technologies used by business actors differs from sector to sector.[62]

SMEs can access digitalization knowledge in Slovenia through different paths. Technology parks, innovation hubs, university incubators, grants, innovation vouchers, tax incentives and supportive coaching services address the Small Business Act (SBA) recommendations in the skills & innovation area[63]. The agency SPIRIT Slovenia[64] launched the first call for a tender for incentives to promote the digitalization of SMEs in September 2017, and 97 companies were awarded. Also, the Chamber of Commerce and Industry of Slovenia (CCIS) offers the Digital Academy to raise awareness of the importance of the digital transformation in SMEs. As a result of the strategic framework Digital Slovenia 2020, the Slovenian Digital Coalition[65] has been established with the aim to assist companies and individual actors in implementing the strategy and to ease the collaboration between stakeholders (industry, research, civil society,

[57] https://www.digital-bw.de/ziele-und-aufgaben
[58] Digitale Transformation von KMUs in Österreich 2019. Erfassung des Digitalisierungsindex 2019. Arthur D. Little.
[59] Operated by "ecoplus. The business agency of Lower Austria", https://www.ecoplus.at/interessiert-an/haus-der-digitalisierung/
[60] https://dih-ost.at/
[61] http://www.noe.gv.at/noe/Topics-in-English/Digitalization_Strategy.html
[62] Digital Economy and Society Index (DESI), 2019 Country Report Slovenia. European Commission.
[63] 2018 SBA Fact Sheet Slovenia. (2018). European Commission.
[64] https://www.sloveniabusiness.eu/
[65] http://www.digitalna.si/en/

public sector and others)[66]. In 2018, the Digital Innovation Hub Slovenia (DIH Slovenia)[67] was founded; it offers different catalogues covering trainings and consulting options.

There are also a variety of initiatives and research centers in Slovenia started in collaboration with companies. Some of the thematic areas include distributed systems development, smart factory, machine vision, blockchain, digital innovation learning, etc.[68]. Companies encourage the usage of IoT and wearables in agriculture for smarter decisions. Additionally, there are projects focusing on smart villages, i.e., developing technologies for biomass processing and development of new biological materials, using secondary raw materials and re-using waste, as well as exploring advanced building materials and products, incl. wood and wood composites[69].

In 2016, Slovenia adopted a strategic document related to the development of information society until 2020. Digital Slovenia 2020 – Development Strategy for the Information Society until 2020[70] presents a commitment for acceleration of development of the digital society. In addition, Slovenia adopted Smart Specialization Strategy (S4) 2014-2020, which implements a platform aiming to increase development investments in areas with critical lack of knowledge and capacity, as well as innovation potential.

In comparison to the majority of companies in Italy (about 55%), which have low investments in digital technologies often having just a simple website and a few computers[71], the digital transformation potential of Trento is remarkable considering the push of the innovation. The province puts forward specialization in a number of sectors related to advanced manufacturing and Industry 4.0 and counts on the strong research capacity of public and semi-public research institutions to innovate, as well as on the capacity of local SMEs.

There are several institutions that support transfer of knowledge and technology from R&D to economy as well as acceleration and education to entrepreneurship and strategic projects. These institutions include business and innovation hubs, foundations, universities, trade associations, etc. Digital Innovation Hub Trentino-Alto Adige[72] offers technology transfer service for enterprises and, following the guidelines of the national plan Industria 4.0, fosters the digitalization process and introduction of technologies developed by the local research institutes. The Chamber of Commerce and Industry of Trento works in the field of market regulation. It offers a service[73] to foster and support the adoption of digital technologies in SMEs. The main scope is to create a network of organizations for tending to enterprises in the digitalization processes. The Alpine Forum on Smart Industry[74] is dedicated to the

[66] Digital Slovenia. (2019). Digital Coalition.
[67] https://dihslovenia.si/en/home-english/
[68] https://www.uni-lj.si/news/news/2019061014161749/
[69] https://ec.europa.eu/info/news/european-commission-supports-call-smarter-future-rural-areas-2018-apr-13_en
[70] https://www.gov.si/assets/ministrstva/MJU/DI/7df0f756bc/Strategija-razvoja-ID.pdf
[71] Digital Economy and Society Index (DESI), 2019 Country Report Italy. European Commission.
[72] https://dih-taa.eu/digital-innovation-hub-trentino/#servizi
[73] Punto Impresa Digitale
[74] https://www.fbk.eu/en/event/alpine-forum-on-smart-industry/

opportunities of the digital transformation of SMEs, innovation intermediaries and administrations.

Piano Industria 4.0 (I4.0) is the Italian plan for companies to benefit from a wide range of measures in order to help them win the challenge set by the digital revolution. The core activities[75] comprise innovative investment, stimulating private investment in the uptake of I4.0 technology, expenditures in R&D, and development of skills. The measures imply tax incentives, access to finances, development of skills related to new technologies and innovative processes stemming Industry 4.0. As part of the strategy, 22 Digital Innovation Hubs are already active providing Italian SMEs with services to facilitate their digital transformation and networking in larger digital value chains.

There are manifold funding opportunities for SMEs with regard to high-tech and digitalization in the Alpine regions, both at the reginal and federal level (federal funding is usually available for companies coming from all regions): grants and innovation premiums, incentives (e.g. subsidies) and other schemes. Specific funding schemes are described in the respective country reports in Annexes 1-4. Companies mention though that it is sometimes quite complicated to obtain such support due to various bureaucratic procedures.

[75] Digital Transformation Monitor: Italy, Industry 4.0. (2017).

Digitalization status of SMEs (survey)

Methodology

In order to understand the status quo of the digitalization of small and medium-sized enterprises in the selected regions, WP2 lead (BIOPRO Baden-Württemberg) elaborated a survey for SMEs that are part of natural fiber-based value chains (agriculture and wood sector). The survey implies a semi-structured questionnaire with 20 questions, open ones and also with multiple choice. Three main aspects were taken into consideration:

- fields of application of digitalization tools in production and management of an SME;
- analysis of needs, obstacles or challenges with regard to the use of the digitalization;
- willingness to adapt new digitalization tools and invest in them.

Potential respondents in Baden-Württemberg, Lower Austria, Slovenia and Trento were chosen by the project partners with respect to the described agriculture and wood value chains. Thus, Baden-Württemberg contacted SMEs that are part of the value chains based on maize. Lower Austria dealt with companies working with hemp. Slovenia and Trento selected SMEs that are part of the value chains based on agricultural waste (mainly from the apple production) as well as the value chains for wood processing and wood application. Companies could participate in the survey in two ways - either to fill in the questionnaire form on a computer and send it back to the respective partner or online. For the second option each partner uploaded the questions on the website *https://surveyplanet.com/* in the native language of the region.

Results

The survey was conducted in November 2019 – January 2020. In total, there were received 30 completed questionnaires, which is less than expected.

14 SMEs represent wood value chains, 16 others belong to agricultural value chains. 10 interviewees out of 30 are micro-enterprises (less than 10 employees), 9 companies are of a small size (11-50 employees), and 10 other respondents are of a middle size (51-250 employees). One company did not want to mention its size. Taking into account the turnover, the majority of the SMEs (17) show the numbers of a micro-company, namely less than 2 million €. This contradicts with the fact that only 10 of them defined themselves as micro-enterprises. Therefore, either some of those companies are not aware of their legal entity status or did not provide the real data regarding their turnover.

The survey was anonymous, thus, almost all participants were reluctant to write their names. Besides, all questions were not compulsory and could be skipped, therefore the number of responses is not always equal to the number of the interviewees. Also, in many cases there were given several answers to the questions with multiple choice by the same respondent.

Industrial sector(s) in which the survey participants operate are covered in the following way:

- Cultivation of biomass / wood procurement, timber harvesting – 6;
- Processing of natural fibers out of biomass / wood processing, e.g. timbering – 12;
- Application of processed natural fibers / construction with wood or furniture production – 11;
- Recycling of products made of natural fibers coming from agriculture – 3;
- Other – 5.

Options		Baden-Württemberg	Lower Austria	Slovenia		Trento		Total
Value chain		Agricul-ture	Agricul-ture	Agricul-ture	Wood	Agricul-ture	Wood	
Number of respondents in total		4	5	5	12	2	2	30
Industrial sector(s) in which company operates (number of replies)	Cultivation of biomass / Wood procurement, timber harvesting	1	2	1	2	-	-	6
	Processing of natural fibers out of biomass / Wood processing, e.g. timbering	-	4	-	5	2	1	12
	Application of processed natural fibers / Construction with wood, furniture production	1	1	-	8	-	1	11
	Recycling of products that are made of natural fibers coming from agriculture	1	-	2	-	-	-	3
	Other	1	1	3	-	-	-	5
Number of employees (number of respon-dents)	Micro (less than 10 employees)	2	3	2	1	2	-	10
	Small (11-50 employees)	1	1	1	5	-	1	9
	Medium (51-250 employees)	1	1	2	6	-	-	10
Annual turnover in 2018 (number of respon-dents)	Less than 2 million €	2	3	3	7	2	-	17
	2-10 million €	1	1	-	3	-	1	6
	More than 10 million €	1	1	2	2	-	-	6

Table 2. Results of the survey for SMEs

Two representatives of Baden-Württemberg in the survey are a maize producer and a company that manufactures compounds out of the biomass. Another SMEs deals with by-products from agriculture and food industry, such as wheat semolina bran, spent grains, apple

pomace. The fourth company recycles dried corn cobs (without drains) and sells them as a substitute of charcoal, e.g. for grilling.

Two respondents of Lower Austria produce hemp and flaw straw out of it. Processors of biomass make technical fibers for insulation bales and textiles, hemp pulp for cigarette paper, flax jeans with 60% of cotton as well as hemp for food purposes. There are also interviewees that deal with agricultural waste materials (not specified).

The SMEs of Slovenia, which are part of the agricultural value chains, recycle animal by-products, render other organic waste treatment and produce biogas. They also work in the beverage production (water, juices, nectars, alcohol). The value chains based on wood and wood waste are represented by timber harvesters, wood processors and constructors. There are also designers of wooden houses as well as exterior (windows, doors) and furniture producers among the respondents.

As for Trento, one company from the value chain for agriculture operates in the application of processed natural fibers and produces quilts and duvets made of wool and cotton fiber. The end products of another SMEs are socks (mainly from the organic cotton) and silk (mainly for sport industry). One of the "wood" respondents operates in wood processing and construction; the second company uses cork panels for the production of wood insulated panels.

The majority of 30 interviewees operate on the domestic market, especially enterprises from Trento; some SMEs have a small share of export (5-30%), two companies are equally active both "at home" and abroad (50%/50%), and the export activities prevail in only one respondent´s business (90%).

Being asked how they assess the degree of the use of digitalization tools, the survey participants showed the results depicted in figure 12 (the numbers in brackets in the legend mean the number of respondents).

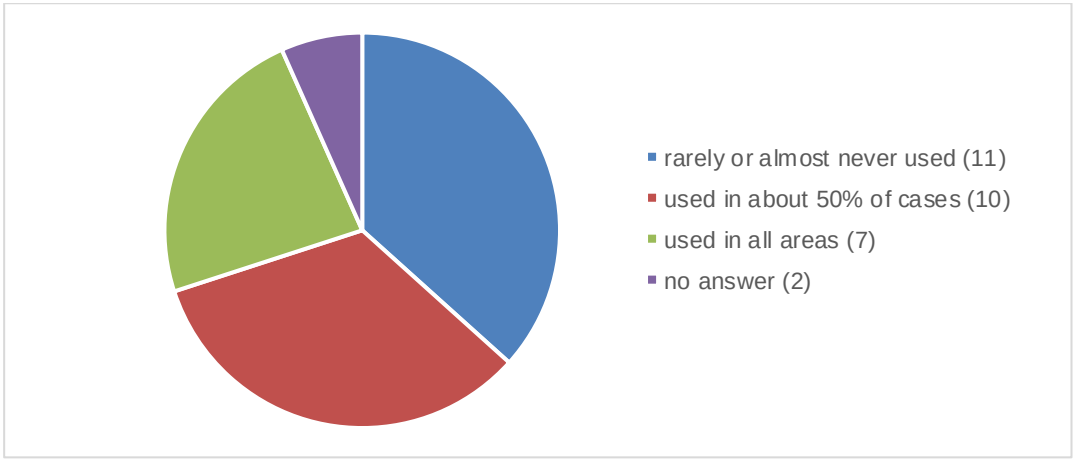

Figure 12. Degree of the use of digitalization tools (self-developed)

The diagram above is the first prove that the digitalization level in the companies dealing with natural fibers is very heterogeneous. The reply that digitalization tools are used rarely or almost not used" given by 11 companies from Lower Austria (3), Slovenia (6) and Trento (2) looks rather surprising for the Alpine region. The SMEs from Baden-Württemberg are slightly more digitalized; they chose either the option "used in all areas" or "used in about 50% of cases".

Responses regarding departments/processes/application areas, in which digitalization tools are already applied by the SMEs, are shown in figure 13 (the numbers in brackets in the legend are the number of responses). Most of all, they are used in the business processes related to general management, production and purchasing. There is a confusing fact though: only three out of four SMEs from Trento replied to the previous question (figure 12), however all four of them mentioned specific departments, in which they actually apply digitalization tools (mainly purchasing).

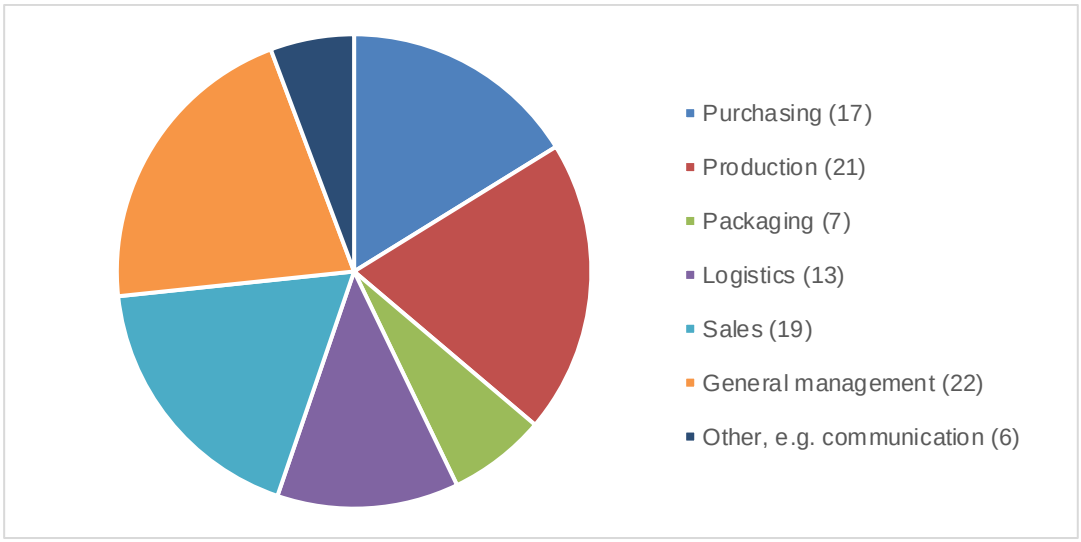

Figure 13. Departments or processes of the company in which digitalization tools are applied (self-developed)

The main obstacles and challenges, which the SMEs face on the way to digitalization, are lack of financial resources and qualified personnel for conducting such changes (figure 14, the numbers in brackets in the legend mean the number of responses).

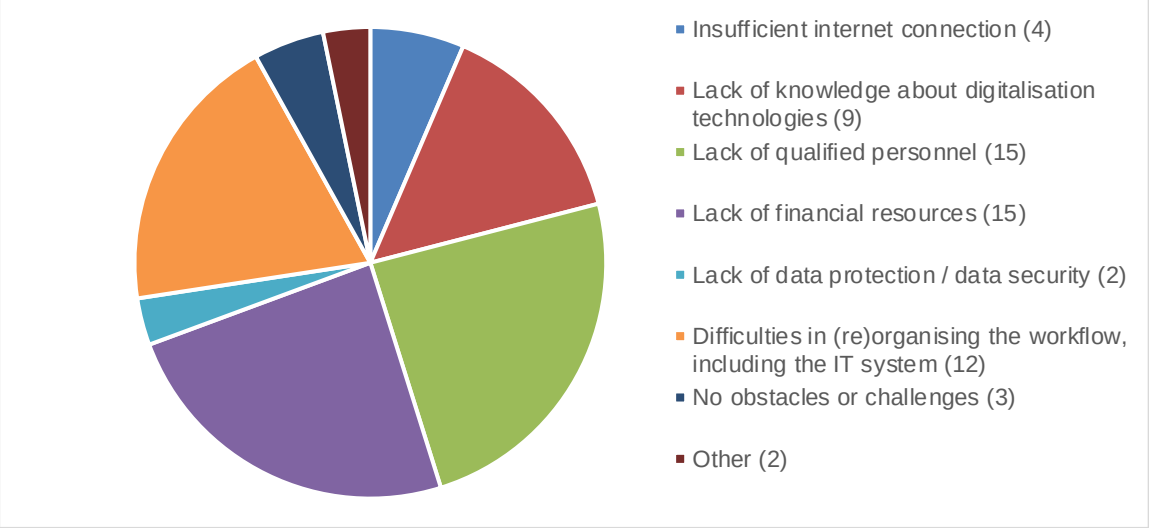

Figure 14. Obstacles and challenges on the way to digitalization (self-developed)

Partly because of the financial issues, the digitalization strategy of the interviewed companies is in the hands of their management. Only four respondents (two from Baden-Württemberg and two from Lower Austria) mentioned that they have an IT-department. Three SMEs (one from Lower Austria and two from Slovenia) replied though that there is no a particular person responsible for the digitalization of the business processes. One company from Trento uses services of an external agency for such purposes.

Speaking about how much money per year is invested in the digitalization activities, the survey participants mentioned from 0,002% to 15% of their operational budget (both extreme values were given by SMEs from Slovenia). If calculated in euros, the range is quite wide, from almost zero to more than 100.000 euros (table 3). It is rather not possible to explain what this depends on. The option 1-5.000 euros was chosen most often.

Option	Baden-Württemberg	Lower Austria	Slovenia	Trento	Total
	Number of respondents				
€ 1-5.000	1	1	5		7
€ 5.000 – 10.000	1	1	1	1	4
€ 10.000 – 50.000		1	4		5
€ 50.000 – 100.000			1		1
More than € 100.000	1		1	1	3
€ 0			3		3
"I do not know"			1		1

Table 3. Amount of the operational budget per year invested in digitalization activities [76]

[76] Not all SMEs answered the questions about financial expenses on their digitalization activities.

In order to increase the digitalization level, the respondents mainly invest in the following measures/actions:

- Acquisition of new or significantly improved hardware and/or software;
- Reorganization of the workflow for integration of new digital work steps;
- Development of new marketing or sales concepts via the Internet;
- Online advertising and promotion;
- Development of the corporate website.

However, IT consulting and introduction of new IT security concepts and applications are not that demanded by the survey participants.

Though not being used evenly by all respondents, the following digitalization tools are already acquired:

- ERP (Enterprise-Resource-Planning[77]), e.g. Navision[78] for orders, receipt of goods, mapping of the current stock levels, invoices, book keeping/accounting;
- MAWI[79] (material management) system;
- BOM (Bill of Materials[80]) is managed in spreadsheet and shared in a filing system, which is covered with digital passwords;
- CRM (Customer Relationship Management[81]);
- CNC (Computerized Numerical Control[82]) machines, e.g. for working with wood;
- Klaes[83] systems, e.g. for tagging pieces with barcodes for later field monitoring;
- Simulation tools in the concept validation process of the design;
- Software for BIM (Building Information Modeling[84]) and 3D modelling;
- Semi-automatic machine control, e.g. planters and harvesters;
- SCADA (Supervisory control and data acquisition[85]) for the control and sensor system of algal ponds;
- Image sensors, environmental sensors;
- E-commerce and e-payment, both for B2B and B2C;
- Self-made programs for logistics planning, monitoring and control of off-road vehicles;
- Shipping interface with logistics service providers;
- Cloud-based document management;
- Electronic systems for recording working time/attendance;
- Management of purchase, warehouse stockings and control of materials´ flows are supported by the Office tools (Excel, Access, Project);
- Communication via the Internet with partners, e.g. per email, Skype, etc.;

[77] https://en.wikipedia.org/wiki/Enterprise_resource_planning
[78] https://en.wikipedia.org/wiki/Microsoft_Dynamics_NAV
[79] https://www.klaes.de/materialwirtschaft.html
[80] https://en.wikipedia.org/wiki/Bill_of_materials
[81] https://en.wikipedia.org/wiki/Customer_relationship_management
[82] https://en.wikipedia.org/wiki/Numerical_control
[83] https://www.klaes.de/index.php
[84] https://en.wikipedia.org/wiki/Building_information_modeling
[85] https://en.wikipedia.org/wiki/SCADA

- Telephones and smartphones.

The most popular tools that the SMEs use to exchange information with clients or partners are traditionally phone and corporate website. Newer services, e.g. online file sharing platforms and messengers, are nor spread that widely in the business communication (figure 15). Mail and digital fairs were mentioned in the category "other".

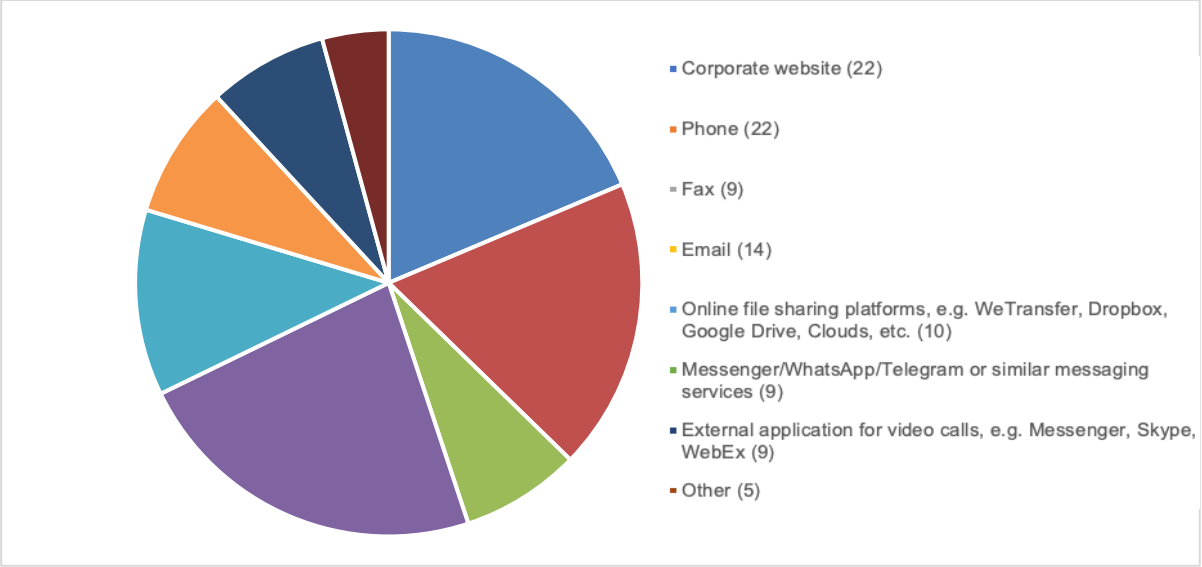

Figure 15. Tools used to exchange information with clients or partners (self-developed)

As for the tools which employees use to exchange information among each other, these are mainly phone, email and interaction in person. Documents are often shared via intranet/central drive folder. Other tools listed above in figure 15 are needed even less than in communication with clients and partners.

The SMEs were also asked whether they have an account in social media to promote their products/services. The prevailing majority (23) do it on Facebook. All participating enterprises from Baden-Württemberg marked this option. LinkedIn and Instagram are used by 8 and 11 respondents accordingly. Twitter and a company`s blog work as a promotional tool accordingly for three and two companies from Slovenia, and only two survey participants from Trento have a YouTube account.

The main goals which the SMEs associate with the advancing digitalization are attracting new customers/new markets, increasing the productivity and level of innovation as well as the reduction of costs. These factors play the most important role for the interviewees (figure 16). Among the answers for the option "other", there were mentioned reduction of mistakes, increased organization and advancing digitalization itself.

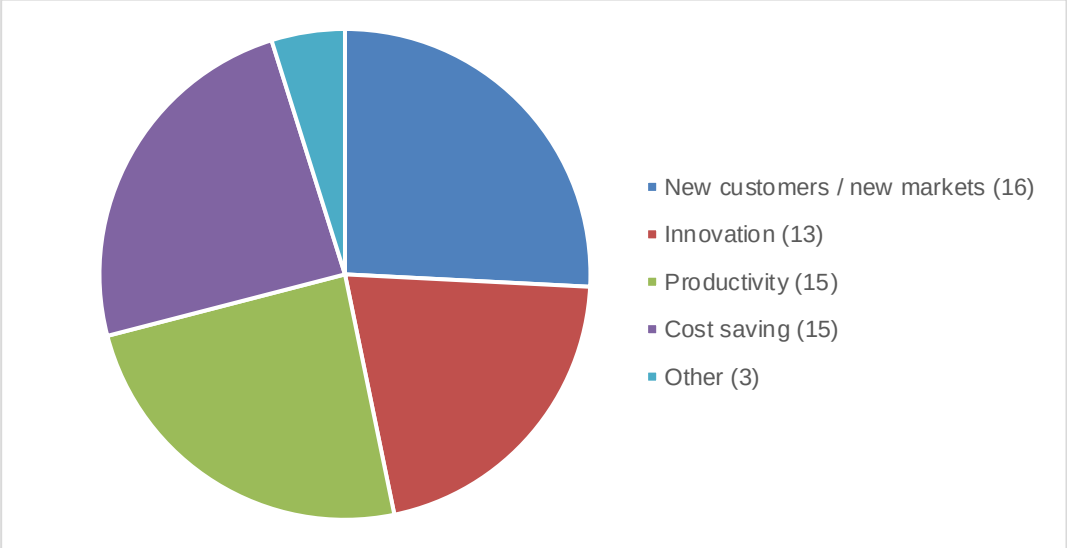

Figure 16. Goals associated with the advancing digitalization (self-developed)

The respondents also mentioned that the digitalization helps in particular sell and promote products/services and thus increases competitiveness, offers consulting services of a higher quality to customers and also reduces mistakes and bureaucracy. One SME from Trento mentioned however that the digitalization does not bring a lot in the production process. After trying to introduce some digital control on machines, it became clear that the work has to be done manually. Several other companies underlined that human skills and expertise are still more important than machinery and digital tools.

The interviewees from Baden-Württemberg organize IT-trainings for their employees at least once a year. A half of the Slovenian respondents have the same approach; others do not provide such option. The companies from Lower Austria mentioned that IT-trainings depend on the needs of staff and are not offered on a regular basis. The SMEs from Trento also do not conduct specific trainings; employees are usually informed by their management about the relevant changes with regard to the digitalization and innovation.

In spite of the existence of various external funding opportunities, also for the adaptation of new digitalization technologies, none of the participants from Baden-Württemberg and Lower Austria receive any targeted support. Slovenian enterprises are aware of the state financial programs and incentives. At the time this report was written, one SME was still waiting for a decision regarding their application. The company aimed to get a voucher for the Digital Strategy and Cyber Security, within which it planned to digitalize the processes of field supply, measurements, assembly and complaints. A survey participant from Trento underlined that application for funds requires too much bureaucracy. Another Italian company admitted the external support that is invested in machines and certifications.

Future digital innovation potential in the production and application of bio-based fibers

The digital transformation in agriculture offers enormous opportunities and at the same time poses major challenges. Technological operating systems based on the artificial intelligence can be the drivers for new organisational models in agri-food production. It can make a significant contribution to the process organization and division of labour, and therefore is primarily concerned with improving the quality of work, occupational health and safety, and making work easier (monotonous and stressful routine work is performed by a robot or other technology). Agricultural enterprises, contractors and machinery rings can optimize production processes and make them more efficient. Moreover, the environment can be protected through the optimized use of resources and operating materials.[86,87]

Bio-based textiles enter significant application fields, for example the high-tech automotive sectors (distance-sensors, car interiors, engine covers and exhaust manifold). Other trends are nutrition for disease prevention, sustainable agriculture, circular and bio-based economy, precision farming, forest management, biodiversity protection and water management.

Bioenergy plays a key role, and for example in Baden-Württemberg it is already the 2nd most important economic pillar for farmers. Wood is also an important supplier of bioenergy. Several bioenergy regions and villages exist in the Alpine space and contribute to the importance of the use of biogenic sources, thus show the possibility to be independent from fossil resources in the future.

Bio-based monomers can be provided for example via lignocellulosic materials, which include wood and its processing residues, straw, other plants like miscanthus, etc. Various research projects and infrastructure for biomass conversion from raw materials into monomers and polymers exist in the project regions but are not yet available at the industrial scale.

In order to spread digital technologies more widely in practice in the industries producing and applying bio-based fibers (e.g. agriculture, wood sector, biotechnology), the following hurdles must be overcome resp. the requirements must be met:

- Sustainable expansion of the digital infrastructure, e.g. broadband mobile communications, reliable internet connection, especially in rural and mountain areas;
- Increase of the reliability of technologies;
- Training and consulting (e.g. farmers are usually not very well educated in the IT field and need a good knowledge basis for taking decisions on investments in such technologies);

[86] Digitalizierung in der Landwirtschaft. Chancen nutzen – Risiken minimieren. (2018). Federal Ministry for Food and Agriculture.
[87] https://digitale-landwirtschaft.com/aktueller-stand-digitalisierung-in-der-landwirtschaft/

- Further regulation of the data protection, security and sovereignty, as well as establishment of further starting conditions (e.g. air traffic regulations for the use of drones);
- Improving the data flow between products from different manufacturers;
- Diminishing the lack of knowledge about biobased products or recycling opportunities outside networks of stakeholders of the biobased industries;
- Increase of the awareness about the topic of digitalization, especially among SMEs, which sometimes consist of only one-two persons who have to deal with a number of daily-basis business activities and simply do not have time to learn about new digital opportunities;
- Further research on benefits of the digital farming[88];
- Active participation in national funding programs for R&D on the digitalization;
- Improvement of the existent and development of new programs on incentives for SMEs willing to accept and undergo new digitalization technologies – this is a task mainly for policy makers.

[88] Digitalizierung in der Landwirtschaft. Chancen nutzen – Risiken minimieren. (2018). Federal Ministry for Food and Agriculture.

Annex

Annex 1. Regional status analysis. Baden-Württemberg

Fundamental economic figures

Baden-Württemberg (BW) has about 11 million inhabitants and a gross domestic product (GDP) of 511,4 billion Euro (data 2018)[1]. In 2018, the innovation index of Baden-Württemberg was 82, which is the best result in the EU[2]. Baden-Württemberg is quite successful in commercialisation of bio-based industry inventions and has the highest number of overall patents per capita in Europe[3].

Parameter	Description
Area of the region/country	35.751 km^2
Land use	Utilized agricultural area = 14.160 km^2 Forest area = 13.718 km^2 Utilized agricultural area: 39,6% Utilized forest area: 38,5%
Main industries in the region	- automotive manufacturing and supply - chemical - electronic - metal - pharmaceutical - optical industries
Industries in which fiber-based sectors can be involved	- housing and construction - furniture - food processing (food supplements) - cosmetics - pharmaceuticals - animal feed - pulp and paper
Percentage of SMEs of the whole economic sector in BW	466.086 MSP (2017) = 99,3%

Table 1. Fundamental economic figures, Baden-Württemberg[4,5]

[1] https://www.statistik-bw.de/GesamtwBranchen/VGR/VW_wirtschaftskraft.jsp
[2] https://www.statistik-bw.de/Presse/Pressemitteilungen/2018291
[3] https://www.statistik-bw.de/Presse/Pressemitteilungen/2016358
[4] https://www.landwirtschaft-bw.info/pb/,Lde/3650826_3651462_5405915_5428928
[5] https://www.statistik-bw.de/GesamtwBranchen/UnternehmBetriebe/040230xx.tab?R=LA

Biomass resources and their application

The agricultural land surface area remained relatively constant in Baden-Württemberg over the years. The number of agricultural companies is constantly declining but the remaining companies have a higher managed surface area; for instance, the average use of agricultural land by a company was 34 ha in 2013, which is about 10 ha more compared to 1999. The land use is diverse with a variety of plants and declining livestock farming. One third of the companies use renewable energy production on their properties. The overall public awareness for sustainability and ecological lifestyle fosters also the amount of organic farming (8%). Baden-Württemberg is ranked 4th in Germany regarding agricultural production value. [6]

As the managed surface area remained relatively constant for more than 30 years, the potential for enlarging agricultural production land seems non-existent. However, new technologies and changing crops allowed an increase in arable production, from 4.7 million tons to 5.3 million tons (grain, maize, corn-cob mix, rape and beet, potato, sugar beets). These technologies are likely to increase (precision and smart farming). Since no clusters exist, a better cooperation of the sector should be aspired. Also, changing consumption patterns and rising ecological awareness of the general public depict a chance to diversify production in terms of the interest of the end user or industry.

38% of Baden-Württemberg is covered with forest (ca. 14,000 km^2). About 24% of this land is owned by the state, 40% are owned by municipals and local authorities and about 36% are privately owned[7]. 11 million cubic meters of timber are cut every year. Main user of this timber is the sawmill industry (65%) followed by log trade (18%). The rest, 4 million cubic meters, is used for energetic purposes.[8]

Strengths of the forestry landscape are high-tech applications for forestry and the well-connected industry in general. The whole forestry sector had a business turnover of 3.5% of total turnover of Baden-Württemberg. 4 out of 11 million cubic meters of wood was used energetically, substituting 910 million litres of heating oil, thereby saving 2.5 Mio tones of CO_2. Chances of the forestry sector are the sustainable economy, side-product usage as a separate business model[9] and new applications of wooden biomass in construction, noting that already 1 out of 4 houses are constructed with wood in Baden-Württemberg[10]. For pulp and paper, general economic upswing enhances the industry. Biobased refineries do not exist in Baden-Württemberg on an industrial scale.

[6] Betzholz, T., Büringer, H., Hartmann, A., Schmauz, S., Schmidt, K., Seitz, R., Thalheimer, F. & Weißenberger, D. (2014). Landwirtschaft und Umwelt in Baden-Württemberg. Reihe Statistische Analysen, 03/2014. Statistisches Landesamt Baden- Württemberg, Stuttgart.
[7] https://mlr.baden-wuerttemberg.de/de/unsere-themen/wald-und-naturerlebnis/waldland-baden-wuerttemberg/
[8] Riedmann, M., Dispan, J., Held, C. & Lückge, F.J. (2010). Clusterstudie Forst und Holz Baden-Württemberg – Analyse der spezifischen Wettbewerbssituation des Clusters Forst und Holz und Ableitung von Handlungsempfehlungen. Ministerium für Ländlichen Raum und Verbraucherschutz Baden-Württemberg
[9] Riedmann, M., Dispan, J., Held, C. & Lückge, F.J. (2010). Clusterstudie Forst und Holz Baden-Württemberg – Analyse der spezifischen Wettbewerbssituation des Clusters Forst und Holz und Ableitung von Handlungsempfehlungen. Ministerium für Ländlichen Raum und Verbraucherschutz Baden-Württemberg.
[10] www.forstwirtschaft-in-deutschland.de/forstwirtschaft/produkte-leistungen/holz/

Nevertheless, agriculture and forestry play only a minor role in matters of the GDP of Baden-Württemberg, with a decreasing tendency. Their current contribution is only about 0.4% of the GDP, which equals only the half of the economic contribution compared to 1991.[11]

Bioeconomy[12] aims not only at making use of primary biomass but also at exploiting the untapped potential stored within millions of tons of biological waste and residual materials. Therefore, it is necessary to understand waste and side streams as valuable resource streams to develop a bio-based and circular economy. Since 2015 the whole biowaste has to be collected separately in Baden-Württemberg. The aim is to provide resources for a high value energetic and material use[13]. Based on data from 2017, there is ca. 50 kg of the organic waste collected per capita in bio-bins annually whereas garden waste amounts 90 kg per year and per person[14]. Collection of the organic waste is associated with the structural condition of public waste disposal companies that are usually tied in long-term contracts of ten to fifteen years[15]. The goal for 2020 is to collect 60 kg of the organic waste per citizen annually[10]. Other sources of secondary biomass resources are green cuttings from public plantings, such as parks or roadside vegetation, side streams of agriculture, aquaculture and forestry (such as saw dust), but for that there is not enough statistical data. The exploitation of these resources can be manifold: composting, fermentation, cascading use, thermic use and other innovative products such as biochar or biorefinery applications.

Value chain mapping

For the fiber-based agricultural value chain in Baden-Württemberg, maize was selected, as it is the second most important field crop in the state, after wheat.

Maize

In 2019, 192.800 ha of maize were cultivated there. Silage maize took up the largest part of the cultivated area, 136.200 ha. 56.600 ha were covered with grain maize. A year earlier, in 2018, 8830 kg/ha of grain maize and 43780 kg/ha of silage maize were harvested[16]. In case of the latter, the entire plant is collected usually when it is still a little green. After harvesting,

[11] Betzholz, T., Büringer, H., Hartmann, A., Schmauz, S., Schmidt, K., Seitz, R., Thalheimer, F. & Weißenberger, D. (2014). Landwirtschaft und Umwelt in Baden-Württemberg. Reihe Statistische Analysen, 03/2014. Statistisches Landesamt Baden- Württemberg, Stuttgart.

[12] "Bioeconomy is a knowledge-based production and utilisation of biological resources, biological processes and principles" to "provide products, processes and services across all economic sectors within the framework of a sustainable economic system."

[13] https://www.lubw.baden-wuerttemberg.de/abfall-und-kreislaufwirtschaft/kompetenzzentrum-bioabfall

[14] Abfallbilanz 2017 – Ressourcen aus unserer kommunalen Kreislaufwirtschaft (2018). Ministry of the Environment, Climate Protection and the Energy Sector

[15] Bio- und Grünabfälle. Optimierung der Erfassung und Verwertung von Bio- und Grünabfällen in Baden-Württemberg, p. 12. (2010). LUBW Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg

[16] ttps://www.maiskomitee.de/web/upload/pdf/statistik/dateien_pdf/Maisanbauflaechen_D_je_BL_in_ha_2018-2019_vorlaeufig_20190802.pdf

the plant is chopped into small pieces and preserved as silage in airtight silos. The silage can be fed to cattle all year round or used in biogas plants. Grain maize is ready for harvest when the plant is completely ripe and dry. Only the corn grains are harvested, and the rest of the plant remains in the field and thus supports the formation of humus. Corn grains contain a lot of energy and are eaten by pigs and poultry. In addition to its importance as a supplier of high-quality food and feed, corn is also increasingly used as an important natural raw material for further industrial processing in the technical-industrial sector, for example, in the starch industry. Corn starch is applied for producing plastics, paper and cardboard, adhesives, packaging and insulating materials, pharmaceuticals, cosmetics, fuels, and abrasives and polishing materials. Another product that can be obtained from corn is corn germ oil rich in fatty acids and vitamin E and extracted from the germ of the corn kernel[17]. Furthermore, semolina and alcohol can be produced from the corn kernel. The corn cob can also be used effectively. Its areas of application are, for example, as fuels, abrasives, sound carriers, floor coverings, hardboard, animal litter, pharmaceutical products, polishing agents, oil binding agents, winter litter or insulation material.[18,19,20]

Figure 17 depicts a value chain starting with the cultivation of maize plant until manifold products through all productional and market phases; there are SMEs in Baden-Württemberg which can be assigned to one or another step of this value chains.

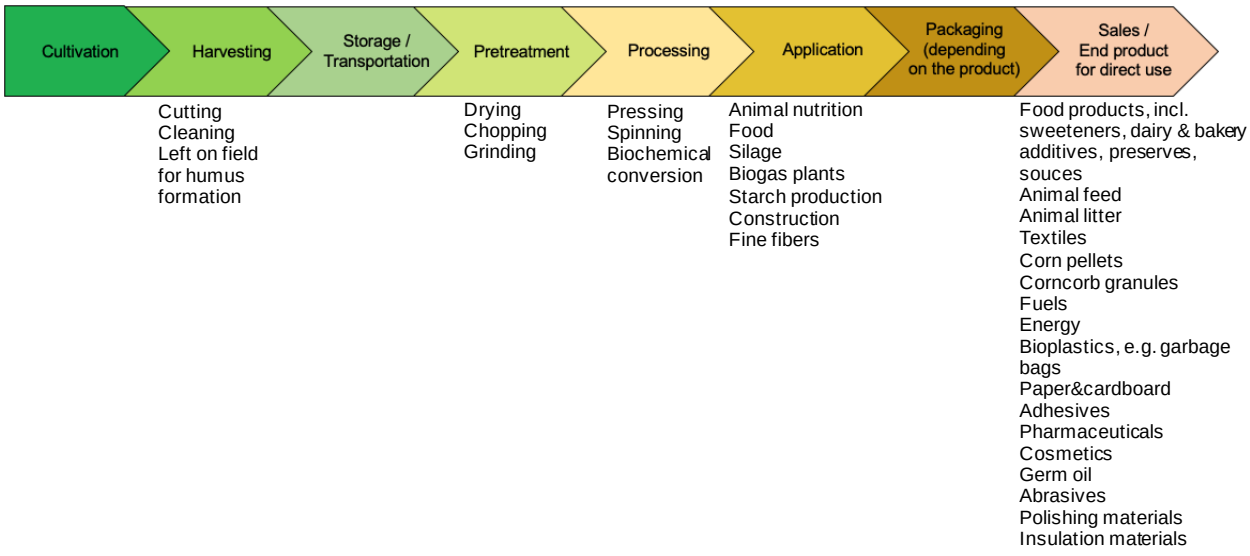

Figure 1. Maize value chain starting from plant cultivation (Baden-Württemberg, Germany)[21]

[17] https://www.vgms.de/staerkeindustrie/lebensmittel/weitere-naehrstoffe/maiskeimoel/
[18] https://www.maiskomitee.de/Verwertung/Industrie
[19] http://maisfakten.de/story/Mais%20zur%20industriellen%20Nutzung%20-%20eine%20umweltschonende%20Alternative%3f
[20] https://www.vdgs.org/sparten/maisstaerke
[21] Self-developed by BIOPRO Baden-Württemberg. (2019).

A value chain based on the recycling of maize as biological waste as well as recycling of products made of the plant in Baden-Württemberg is presented in figure 18.

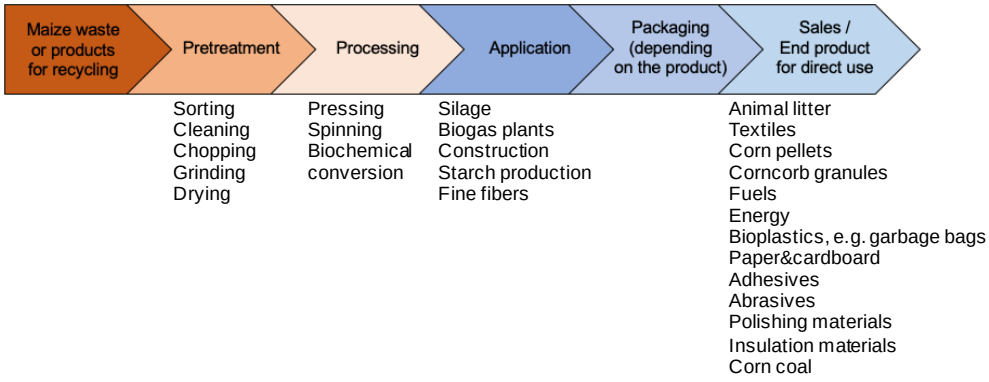

Figure 2. Maize value chain starting from recycling (Baden-Württemberg, Germany)[22]

One of the most sustainable applications of the corn cob existing in Baden-Württemberg is using it as a corn coal, for example, as an adequate alternative to charcoal for barbecue. The idea was invented by the start-up Kolbenglut.[23]

Digitalization knowledge ecosystem

Digitalization is a very present topic in Baden-Württemberg and the access to such knowledge is available to SMEs in various ways. Despite the fact that SMEs account for more than 99% of all companies in the region, their input in the entire innovation expenditure of Baden-Württemberg industry is only 11%[24].

In order to support SMEs, the Ministry of Economic Affairs, Employment and Housing (WM) of Baden-Württemberg has launched the initiative "Industry 4.0"[25]. Furthermore, several cross-industry projects have already been initiated within the framework of the initiative "Wirtschaft 4.0"[26]: digital hubs, digitalization premium, innovation voucher "High-Tech Digital", and the contest of ideas for knowledge and technology transfer.

The Digital Innovation Center (DIZ)[27] is a joint initiative of CyberForum e.V. and the FZI Research Center for Information Technology. As a virtual competence center, it bundles

[22] Self-developed by BIOPRO Baden-Württemberg. (2019).
[23] https://www.kolbenglut.com/#start
[24] https://www.baden-wuerttemberg.de/fileadmin/redaktion/dateien/PDF/200204_Innovationsstrategie_BW_Fortschreibung_2020.pdf, p. 51.
[25] https://wm.baden-wuerttemberg.de/de/innovation/schluesseltechnologien/industrie-40/allianz-industrie-40-bw/
[26] https://wm.baden-wuerttemberg.de/de/innovation/initiative-wirtschaft-40/
[27] https://www.diz-bw.de/

existing resources and the know-how of the partners and realizes the basic idea of digital transformation through comprehensive networking. The strong medium-sized businesses in Baden-Württemberg benefit from this special alliance of scientific and economic players. The goal is to support the economy of Baden-Württemberg, in particular SMEs, in their efforts for digitalization in a sustainable manner and thus to advance the digital transformation in the state holistically.

The regional Digital Hubs[28] are unique crystallization points for digital innovations in Baden-Württemberg where the most diverse competencies, disciplines, ideas, technologies and creativity come together. They are regional contact points for SMEs of all industries for questions regarding digitalization. There, companies can also test new ideas for digital projects in experimental rooms.

The project "Business Innovation Engineering Center" (BIEC)[29] is also funded by the WM. It is run by Fraunhofer IAO and the Institute for Labour Economics and Technology Management IAT of the University of Stuttgart for the period of April 2018 - March 2022. Based on the excellent scientific expertise, the project provides SMEs with the knowledge on innovation at the services and business level as well as at the organizational and management level, e.g. smart products, digital and data-driven business models.

Measurement of the level of digitalization

In order to understand the level of digitalization, the WM has initiated the "Digital economic index"[30]. Based on 1.124 interviews with companies in Baden-Württemberg, the index measures the degree of digitalization of business processes, internal company procedures and workflows as well as the intensity of the use of new digital technologies and services. The survey lead to the following results:

- The digital economic index of Baden-Württemberg is 55 out of 100 possible points, whereas Germany´s index at the federal level is 54;
- Commercial industry in Baden-Württemberg is slightly more digitalized than at the federal level; 24% of commercial enterprises in the region are "highly" digitalized;
- ICT[31] sector is the digital pioneer with 74 index points;
- Digitalization is driven by service companies; their average index is 57, which is significantly more than 44 points of the manufacturing industry (knowledge-intensive service providers (62), creative industries (62), financial / insurance service providers (61) and trade (55));
- Micro enterprises (1-9 employees) have a higher degree of digitalization (index 55) than small and medium-sized (10-249 employees) and large enterprises (250

[28] https://www.digital-bw.de/-/regionale-digital-hubs
[29] https://biec.iao.fraunhofer.de/de/ueber-uns.html
[30] Bertschek, I., et al. (2018). Monitoring-Report 2017 – Wirtschaft DIGITAL Baden-Württemberg. Ministerium für Wirtschaft, Arbeit und Wohnungsbau Baden-Württemberg.
[31] Information and communications technology

employees and more). The economically significant large enterprises have on average 54 points. However, SMEs are lagging somewhat behind overall and only achieve 52 points in the index in Baden-Württemberg, therefore special attention must be paid to SMEs in the digitalization process.

Another study, "Digitization Index for small and medium-sized enterprises 2019/2020"[32], in which 2.095 SMEs took part, shows that German SMEs are continuously working on their digital transformation. The majority of companies are now convinced that this is the only way to remain competitive and work more productively in the long term. Even more decisive: every second company (51%) now sees digitalization as a strategic project. The study results are quite similar to the survey or "digital economic index". The graph in page 9 of the study (here - figure 3) shows the main fields in the focus of digital efforts: improvement of customer relations as well as data protection and data security.

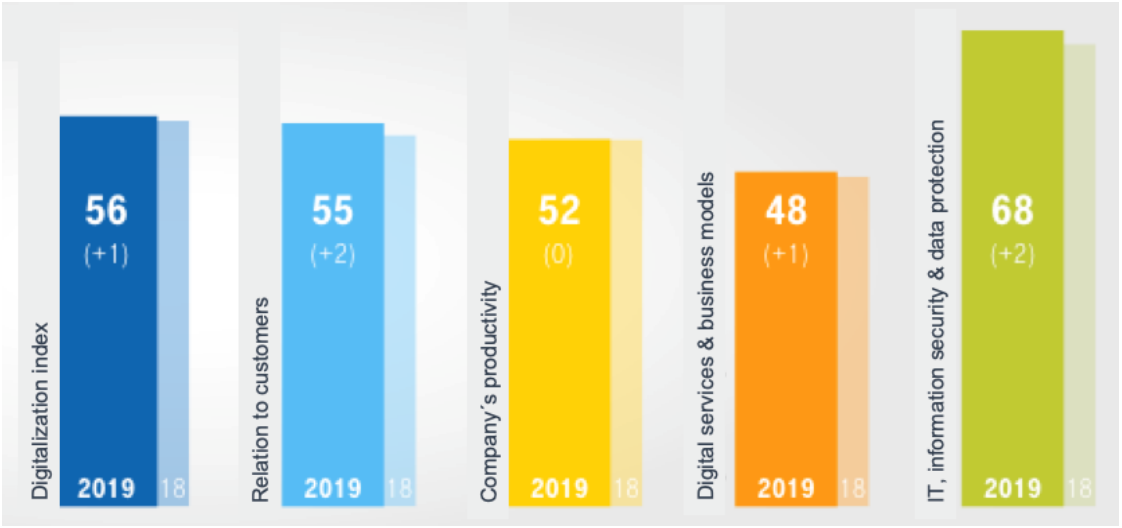

Figure 3. Index values of the digital fields of action (index 0-100 points)[33]

Political framework for digitalization

The first state-wide interdisciplinary digitalization strategy **"digital@bw"**[34] was presented in 2017. It contains a large number of innovative projects and measures, for which implementation the Baden-Württemberg government provides around 1 billion euros by 2021 under the supervision of the Ministry of the Interior, Digitalization and Migration. The strategy

[32] Digitalization index for small and medium-sized enterprises 2019/2020. The digital status quo of German small and medium-sized enterprises. (2019). Study by Deutsche Telekom AG, Corporate Communications.
[33] Same as reference 25, p. 9.
[34] https://www.digital-bw.de/-/alles-beim-neuen

is intended to show where digitalization should and can lead in the future if the right course is set. The strategy goals are following[35]:

- Focus on the population of Baden-Württemberg, demonstrate concrete benefits of modern digitalization technologies to the people with the help of innovation projects and pilot schemes;
- Create and strengthen innovative solutions for the digital age using new technologies, business ideas and start-ups in the high-tech sector in Baden-Württemberg, thus secure jobs and value creation;
- Provide excellent training for junior staff and be an attractive location for the best talents worldwide;
- Support local authorities in shaping central policy areas such as mobility, education or health in urban and rural areas in a future-oriented and sustainable manner;
- Ensure the data protection, data security and data sovereignty of the population and companies;
- Be committed to cooperation by setting up projects across departments and interdisciplinary teams within and outside the state government;
- In addition to the state's own budget funds, obtain other sources of financing for the planned projects, including federal and EU funds.

The digitalization strategy of BW has a lot in common with the German federal **High-Tech Strategy 2025**[36]. It sets the goal of continuing the upward trend in R&D investment and spending on that at least 3.5% of the country´s GDP (3,465,99 billion euros in 2019[37]) - ca. 120 million euros by 2025, together by the Federal States and the private sector. The Strategy focuses on three major fields of action:

- Tackling the grand challenges. Research must be geared to current and future needs and relevant to people's everyday lives. The goal is to achieve technological and non-technological innovations, including social innovations, which focus on benefiting the people. To achieve this, the support from science, business and society is needed. The main areas of the research are 'Health and Care', 'Sustainability, Climate Protection and Energy', 'Mobility', 'Urban and Rural Areas', 'Safety and Security', and 'Economy and Work 4.0';
- Strengthening Germany's future competencies. Promoting key enabling technologies that also open up new and disruptive innovation potential with their broad range of applications and strengthen the economy in international competition;
- Establishing an open innovation and venture culture. For innovative results, innovative forms of cooperation and networking are needed that create spaces for ideas and involve new actors in the innovation process.

[35] https://www.digital-bw.de/ziele-und-aufgaben
[36] The High-Tech Strategy 2025. Research and Innovation that benefit the people. The Federal Government of Germany. https://www.bmbf.de/upload_filestore/pub/Research_and_innovation_that_benefit_the_people.pdf
[37] https://de.statista.com/statistik/daten/studie/1251/umfrage/entwicklung-des-bruttoinlandsprodukts-seit-dem-jahr-1991/

In February 2020, Baden-Württemberg introduced its **Innovation Strategy**[38]. Priority at the state level is given to investments in the growth and future-oriented areas, such as digitization and digitalization, artificial intelligence and industry 4.0, sustainable mobility, health care, resource efficiency and energy system transformation, and sustainable bio-economy. One of the Strategy´s goals is also strengthening the innovative potential of SMEs, especially those which are willing to invest in research and development. Moreover, the state also wants to use EU funds to further expand the research infrastructure at universities and in business-related institutes and to improve the structures of technology transfer from science to SMEs.

Funding schemes for high-tech development and digitalization of SMEs

There are manifold funding opportunities for SMEs with regard to high-tech and digitalization both at the reginal and federal level (federal funding is usually available for companies coming from all regions, including Baden-Württemberg). In this report only some of them are described.

Federal funding program "go-digital"[39]

The program is funded by the Federal Ministry of Economics and Energy (BMWi) and supports SMEs and handicraft enterprises in advancing their own digitalization in three areas: online trade, digitalization of everyday business life, growing need for security in digital networking. Criteria for receiving funding:

- Less than 100 employees;
- Annual turnover or annual balance sheet total for the preceding year not exceeding 20 million euros;
- Establishment or a branch office in Germany;
- Eligibility to be supported under the De-minimis-regulation.[40]

Funding is provided for consulting services in a selected main module with any necessary auxiliary modules at a funding rate of 50% up to a maximum daily consultant rate of 1100 euros. Funding is provided for a maximum of 30 days within a period of six months.

Regional funding program "Innovation voucher High-Tech Digital"[41]

It is a similar to "go-digital" initiative but at the level of BW under the WM´s supervision. The program is intended to support demanding R&D projects of established companies that aim to develop digital products and services. Criteria for receiving funding:

[38] https://www.baden-wuerttemberg.de/fileadmin/redaktion/dateien/PDF/200204_Innovationsstrategie_BW_Fortschreibung_2020.pdf
[39] https://www.bmwi.de/Redaktion/DE/Artikel/Digitale-Welt/foerderprogramm-go-digital.html
[40] https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32013R1407
[41] https://wm.baden-wuerttemberg.de/de/innovation/innovationsgutscheine/innovationsgutschein-hightech-digital/

- Annual turnover or balance sheet total 20 million euros with less than 100 employees, in case of 250 employees the annual turnover can amount up to 50 million euros;
- Headquarters in BW.

Financial support is provided to the projects in the following fields: solutions for the digital transformation of business models, also in related to Industry 4.0; networked systems and processes; Internet of things; smart services; highly flexible automation; big data, etc.
The voucher amounts to up to 20.000 euros and covers a maximum of 50% of the expenses charged to the company. Applicants can be awarded with a maximum of two High-Tech Digital innovation vouchers.

Federal funding programs "Innovative SMEs: Material science (ProMat_SME)" [42] and **"Innovative SMEs: Biotechnology – BioChance"** [43]
The programs are funded by the Federal Ministry for Education and Research and focused on fostering the innovation capacity of SMEs. Application deadline is unlimited, every six months; assessment is always on 15th of April and 15th of October. Precondition for funding is high risk of projects. Possible fields/topics are health care industry, sustainable construction and infrastructure, sustainable usage of raw materials, materials for mobility and transport, modern biotechnology, etc. In case of biotechnology, the projects with the focus on the National Research Strategy BioEconomy 2030 [44] are preferred.

Federal funding program "Forestry 4.0 – Digitalisation and sustainable development of technology" [45]
Funding is issued by the Federal Ministry for Food and Agriculture to support R&D in order to maintain and strengthen sustainable and multi-functional forestry. To provide employment and economic growth, especially in rural areas, forestry needs to better capture data as well as connect its respective processing steps in the wake of increasing automatization. As a result, projects to be funded need to outline research areas such as:

- Development of open standards to be used on digital data-sharing platforms;
- Incorporation of all steps and recognition of all actors along forestry value chains;
- Use of digital twins as a means of modelling and planning of forestry specific process steps, e.g. forest management, use of machinery, forest worker equipment harvesting and logistics;
- Attention to questions regarding the use of data, in particular personal data.

Regional funding program "Spitze auf dem Land!" [46]
Objective of the program is increasing innovative strength and maintaining technological leadership in rural areas. SMEs with less than 100 employees are supported by the Ministry

[42] https://www.bmbf.de/foerderungen/bekanntmachung-1087.html
[43] https://www.bmbf.de/de/kmu-innovativ-561.html
[44] https://www.pflanzenforschung.de/files/4514/7886/1937/German_bioeconomy_Strategy_2030.pdf
[45] https://www.fnr.de/projektfoerderung/fuer-antragsteller/aktuelle-bekanntmachungen/?__msstto=en
[46] https://efre-bw.de/foerderaufruf/spitze-auf-dem-land-fa/

for Agriculture and Consumer Protection of BW and L-Bank with a grant that can be invested in development and application of innovative products and processes. They should be highly technologically developed and suit for rural area purposes. The grant amounts 200.000-400.000 euros with the funding rate up to 20%.

Future innovation potential in Baden-Württemberg

Innovation index is calculated every two years by the Statistical Office of Baden-Württemberg. It is a comparison of 86 regions (28 EU member states and 58 regions). According to the data of 2018, Baden-Württemberg has still the highest innovation capacity within the EU – 82 index points.[47]

Thanks to digitalization, the innovation potential of the industries, which produce or apply bio-based fibers, are considered to be quite high. The digital transformation in agriculture offers enormous opportunities and at the same time poses major challenges. It can make a significant contribution to the process organization and division of labour, and therefore is primarily concerned with improving the quality of work, occupational health and safety and making work easier (monotonous and stressful routine work is performed by a robot or other technology). Agricultural enterprises, contractors and machinery rings can optimize production processes and make them more efficient. Agricultural machinery, crop protection and fertilizer manufacturers, feed manufacturers and agricultural consultants are able to tailor their services even more individually and efficiently. The costs of products, inputs and services can be reduced by using digital systems. Moreover, the environment can be protected through the optimized use of resources and operating materials.[48,49]

In Baden-Württemberg, there are quite significant numbers of cluster initiatives and enterprises that are making direct use of bio-based applications. Bio-based textile & clothing is already in the scope of interest in Baden-Württemberg. 100% bio-based sustainable and fair-trade clothes are on the market but are still niche products. Bio-based textiles are entering significant application fields and especially in the high-tech automotive sectors, bio-based solutions have entered the market (distance-sensors, car interiors, engine covers and exhaust manifold).

Bio-based monomers can be provided for example via lignocellulosic materials, which include wood and its processing residues, straw, other plants like miscanthus and many more. These materials can nowadays be converted into valuable compounds via a diverse tool box of processes. Thus, reasonable provision of raw materials and residues can interlink the agriculture and forestry sector with the chemical sector. Many more research projects and infrastructure for biomass conversion from raw material to monomers and polymers exist in Baden-Württemberg but are not yet available at industrial scale.

[47] https://www.statistik-bw.de/Presse/Pressemitteilungen/2018291
[48] Digitalizierung in der Landwirtschaft. Chancen nutzen – Risiken minimieren. (2018). Federal Ministry for Food and Agriculture.
[49] https://digitale-landwirtschaft.com/aktueller-stand-digitalisierung-in-der-landwirtschaft/

Bio-based polymers are used in Baden-Württemberg for the application in several sectors, but the major production of bio-based chemicals and polymers is located in other regions of Germany. Regarding the strong industry in Baden-Württemberg on the application side, purchase of bio-based chemical building blocks from other regions must be considered as a significant bottleneck.

Bioenergy plays a key role in Baden-Württemberg and is already the 2nd most important economic pillar for farmers. Baden-Württemberg was the first German state to pass a law for renewable energy for heat utilization from bioenergy in the building sector in 2008. As part of the long-term goal for the restructuring of the energy sector, the aim of the state government is to increase primary energy from renewables (including bioenergy) up to 80% until 2050. Wood is also an important supplier of bioenergy. Several bioenergy regions and villages exist in Baden-Württemberg, contributing to the importance of use of biogenic sources and showing the possibility to be independent from fossil sources in the future.

There is a great potential in the digitalization of the health care system to master current challenges, such as demographic change. In terms of the performance of the digital healthcare industry and the strategic integration of digital technologies in healthcare, for example by initiating telemedical projects, Baden-Württemberg is positioned on the top in comparison with other German federal states. One exception is the liberalization of the remote treatment ban in Baden-Württemberg as the only state to date that can make innovative telemedical solutions possible in the future.[50]

[50] Bertschek, I., et al. (2017). Metastudie: Chancen und Herausforderungen der Digitalisierung in Baden-Württemberg. Ministry of Science, Research and Arts of Baden-Wuerttemberg, Ministry of the Interior, Digitisation and Migration of Baden-Wuerttemberg, State Ministry of Baden-Wuerttemberg.

Annex 2. Regional status analysis. Lower Austria

Lower Austria is one of the nine federal states of Austria, located in the northeast of the country. It borders on the Czech Republic and Slovakia, and the federal states of Upper Austria, Styria, and Burgenland. Geographically, it encloses Vienna, which in juridical terms is not part of the region but has a substantial influence on its economy.
Lower Austria is surrounded by high-growth markets in Central and Eastern European and is supported by strong networking with the economic region of Vienna which gives the region significant geographic advantages and thus, an investment friendly climate.

Fundamental economic figures[1]

Parameter	Description
Land use	Farmland = 42% Wood and Forestry = 40% Grassland = 11% Alpine Pastures = 1,7% Vineyards = 1,9%[2]
Regional GDP	In 2016, regional GDP in Lower Austria was € 55b, accounting for about 15,6% of Austrian GDP (Eurostat, 2018). Lower Austria is therefore the third most important Austrian region, right behind Upper Austria with 16,9% of Austrian GDP and Vienna with 25,5% of Austrian GDP. GDP per capita reached € 30.400 amounting to 81,7% of the national average (Eurostat, 2018). With exports of €21,8b (2017), Lower Austria ranks second nationally (after Upper Austria with €36,5b) accounting for 14.4% of national total exports. The exports and imports are quite balanced in Lower Austria since the region imports €24,7b which represents 14,0% of the national total imports (Statistics Austria, 2018).
Main industries in terms of level of employment and revenue/turnover	The economically active population amounted to 0,859 million, 19,1% of national total (2017) which ranks Lower Austria at the second place, behind Vienna with 0,939 million active people (Eurostat, 2018). The sectoral distribution of employment (5,6% in agriculture, 22,6% in the industry and 71,8% in the service sector) indicates an above average focus on the agricultural sector compared to the national average (3,8%, 25%, 71,2%) (2017). In 2017, Lower Austria's unemployment rate of 4,8% (Eurostat, 2018) was low by national standards (5,5%).
Industries in which fiber-based sectors can be involved	No percentage available. Preferred sectors in which fiber-based sectors along the value chain can be included: • Textile industry • Technical industry textiles • Construction textiles • Home and clothing textiles

[1] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/lower-austria
[2] https://en.wikipedia.org/wiki/Lower_Austria

	• Farming • Raw materials, straw, wood, natural fibers • Plastics industry • Taple fibers, filaments, blended fabrics (natural and synthetic fibers) • Paper industry • Cellulose • Machine and process
Percentage of SMEs of the whole economic sector in general	According to the Austrian Institute for SME Research 99,6% of all companies are SMEs which totals to an absolute number of SMEs of 337.800 employing almost 2 million people generating a turnover of EUR 482 billion[3]. In Lower Austria, there are 104.574 companies of which 63,4% are single-person-enterprises, 29,3% very small and 7,1% small to medium-sized enterprises, only 0,2% are large companies[4]. There is no real sectorial focus, it is a relatively heterogeneous structure in terms of business sectors, many different branches are active in Lower Austria but the main thematic fields are reflected by the Lower Austrian Clusters, which are: • Green Building Cluster of Lower Austria (*2001) • Food Cluster of Lower Austria (*2006) • Plastics Cluster (*2005) • Mechatronics Cluster (*2010) • e-Mobility Initiative in Lower Austria (*2010)

Table 1. Fundamental economic figures, Lower Austria

Value chain mapping

Hemp is one of the most important agricultural plants in Lower Austria. It is usually planted in April; leaves are harvested in June and corns in September. Yields are amount 600-1000 kg/ha; produced later on fibers are counted with 3-4 t/ha. Hemp allowed for consumption is applied for production of food and supplements (snacks, muesli, cookies, chocolate, tea, oil). Hemp protein powder is used as a food additive. Moreover, hemp is applied in husbandry, e.g. animal feeding, and veterinary products. Fibers are also interesting for producers of paper, textiles, thermal insulation materials, plastic composites for cars, etc.

Figure 1 depicts a value chain starting with the cultivation of hemp plants up to products through several production phases.

[3] https://www.kmuforschung.ac.at/facts-and-figures/kmu-daten/?lang=en
[4] https://www.ecoplus.at/media/6518/unternehmerland_noe_engl_web.pdf

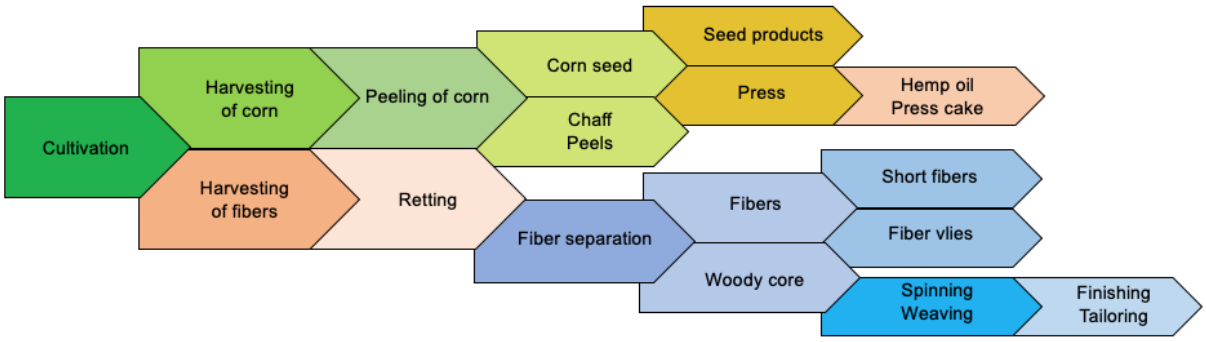

Figure 1. Hemp value chain starting from cultivation (Lower Austria)[5]

The focus of the activities within the value chain is on the use of hemp with its manifold possibilities. The added value is to be achieved from the multitude of individual products together. The value chain is thus not linearly aligned to one (or several, parallel) product(s), but to the use of the individual ingredients in the sense of the whole plant use. Recycling of hemp is not carried out in Lower Austria since it is simply burnt.

Digitalization knowledge ecosystem

According to the study carried out by Arthur D. Little in September 2019, to evaluate the digital transformation of companies in Austria and to evaluate the digitalization index of Austrian and respectively Lower Austrian SMEs it can be said that the digitalization index has increased throughout all branches by 30% to 37%, the size of the company with regards to the digitalization index is therein insignificant, digitalization has also reached SMEs in the same extent as well as bigger companies. In general, the awareness of digitalization and the attitude towards digitalization developed towards a positive trend meaning SMEs do not see it as a threat but as a chance for future business.[6]

The initiative **Economy 4.0** aims to raise more awareness for digitalization and networks, and its potential for future business growth.

In 2018, the Lower Austrian Department of Economic affairs published a specific plan describing how to reach the goals of the initiative, which are focused on:

- Raising awareness through events dedicated to the initiative and pursue a stronger cooperation with Clusters in Lower Austria and Technology and Innovation Partners (TIP);

[5] Self-developed by the Institute for Industrial Ecology, St. Pölten, Lower Austria. (2019).
[6] https://www.wko.at/branchen/noe/information-consulting/unternehmensberatung-buchhaltung-informationstechnologie/kmu-digitalisierungsstudie-2019.pdf

- Support the change through financial support schemes, new technologies and investment solutions;
- Offer training to develop new skills and focus on qualifications that will be beneficial to the Economy 4.0 initiative.

Lower Austria features a diverse and broad ecosystem to foster innovation and digitalization. **The House of Digitization** can build on the support of several actors, including ecoplus, the business agency of the region, as well as the chamber of commerce. The Digital Innovation Hub also cooperates closely with the six research institutions of the different technopoles across the region. The ecosystem is complemented by a number of incubators and investors, which provide start-ups and other businesses with advice, support, and the financial means to develop new ideas or to strengthen digitalization in the region.

The **House of Digitalization** (operated by ecoplus. The business agency of Lower Austria and funded by ERDF and national funds) is the lighthouse project of the Lower Austrian digitalization strategy. It is a one-stop-shop addressing the needs for digitalization of SMEs in Lower Austria. It is a platform that offers companies and researchers to connect interests, digital skills, expertise and it provides knowledge and networks customized to the local setting. As such the House of Digitalization is the center for technological change in education, science, business and administration in Lower Austria.

The Network
Since spring 2018, an intelligent network has been established in the course of which six "digital nodes" (= hubs) have been developed in Klosterneuburg, Krems, St. Pölten, Tulln, Wiener Neustadt and Wieselburg. These small digital hubs are closely linked together, as well as connected with other existing expert networks. So-called node managers (or hub managers), representatives from business, administration, universities of applied sciences and research centers, are bundled in a cross-institutional and Lower Austria-wide competence network.

The Virtual House
In January 2019, an interactive online platform with personalized services and an automatic recommender system was launched, in order to network Lower Austrian companies with research and educational institutions, as well as being a meeting point for interested citizens in the field of digitalization.

DIHOST (Digital Innovation Hub OST)
DIHOST is one of three digital innovation hubs in Austria funded by the FFG. The project, operated by ecoplus, the business agency of Lower Austria, offers a comprehensive three-year service program to increase the transformation capacity and transformation speed of SMEs in Eastern Austria (Lower Austria, Upper Austria, Burgenland and Vienna) towards digital innovations.

Main drivers for innovation in digitalization

To foster innovation and bundle resources, the region identified four "technopoles". These technopoles are regional research and innovation platforms intended to facilitate knowledge sharing between research institutes, tertiary educational institutions and companies. ecoplus, The business agency of Lower Austria plays the key role as a mediator between different actors and facilitates the exchange and innovation. Each technopole focuses on a different theme:

- health technology in Krems;
- natural resources and biobased technologies in Tulln;
- medical and material technology in Wiener Neustadt;
- bioenergy, agricultural and food technology in Wieselburg.

In addition, the region identified four thematic clusters in which, coordinated by ecoplus, companies and research institutions in the region do research on and innovate in four promising economic fields. These four clusters focus on green building, food production, plastics, and mechatronics.

The main driver of innovation in digitalization is the ability to significantly improve the visibility of SMEs and directly reach global customers. Communication, mobility, efficiency improvement, smart information, smart technologies, services, payment systems, crypto currencies, block chain. Especially in agriculture, the available satellite observation opens up completely new possibilities. Optimization of crop rotation, fertilizer application, pest control, self-propelled working machines, remote control of work processes in the field, optimization of feed application, early detection of diseases through evaluation of movement profiles.

Since the agricultural sector is respectively high in Lower Austria (42% of the land used as farmland, as mentioned above) here the bigger, more influential farmers which have to compete on the European or global markets do push smart farming/ precision farming activities as it is a simple question of affordability and time span to amortization of certain investments. Given the heterogeneous economic structure within Lower Austria and the very high Single-Person-Enterprise and SME-Share of 99,6% where the CEO is mostly busy with day-to-day business one could put out the generalized presumption that these companies do not actively push the development but as always this depends on various factors (likelihood of CEO to innovate and to think about strategic moves, pain of other problems more urgent than digitalizing one`s business).

Direct marketing of the produced products to the consumer through online shops, and many more fields of application are seen as a chance for further business model development.

Measurement of the digitalization level

At present there are no concrete figures for Lower Austria. However, digital technologies are already being used in many areas of agriculture, e.g. GPS controlled tractors, drone supported data acquisition, soil conditions, fertilizer requirement analysis, recording of the livestock with tracking systems, control of feeding automats individualized for each animal.

Regarding the measurement and indicators of the digitalization level, the Lower Austrian Digitalization Strategy does not describe that; it says though: "All activities and measures will be documented and made available in a progress report. The implementation of the measure and the impacts thereof will be periodically evaluated. A scientific advisory committee of international experts will supervise and assist with this process." [7]

Political framework for digitalization

Digitalization and the associated solutions and applications open up new opportunities and prospects for the regions and society, businesses and institutions. The mission of the digitalization strategy of Lower Austria is to Use the digital transformation. For country and people. Three goals shall be pursued with the digitalization strategy and the associated projects and measures: secure and create new jobs, strengthen rural regions, and improve the quality of life. To achieve the digitalization goals it is important that people, businesses, and the public sector are fit for digitalization; the necessary infrastructure is comprehensively expanded and continuously upgraded, and digital innovations and solutions are promoted. Manifold measures have been developed for that. Further measures are continuously being added.[8]

Funding schemes for digitalization

There are various funding possibilities available. One of them is offered by the TIPs (Technology and Innovation Partners) located within the Chamber of Commerce [9]. Furthermore, the Regional Government of Lower Austria has launched a call for the conception and implementation for commercialization projects regarding digitalization [10]. An overview of all calls launched and funding opportunities related to digitalization by the Regional Government of Lower Austria is given online[11,12]. Besides, various calls are launched by the managing bodies of national and international funds[13,14,15].

[7] http://www.noe.gv.at/noe/Topics-in-English/Digitalisierung_Folder_Englisch.pdf, p. 27.
[8] http://www.noe.gv.at/noe/Topics-in-English/Digitalization_Strategy.html
[9] https://www.wko.at/site/tip/TIP-Startseite.html
[10] http://www.noe.gv.at/noe/Wirtschaft-Tourismus-Technologie/Foerdercall_Wirtschaft_4.0.html
[11] http://www.noe.gv.at/noe/Foerderungen_Digitalisierung.html
[12] https://www.ecoplus.at/newsroom/foerdermoeglichkeiten-zum-thema-digitalisierung-in-unternehmen
[13] https://www.ffg.at/foerderungen
[14] https://www.wko.at/service/innovation-technologie-digitalisierung/innovationsfoerderung.html
[15] https://www.aws.at/foerderungen/aws-industrie-40/

Future digital innovation potential

There are some of the world's leading high-tech companies in the field of agriculture In Lower Austria. "Busatis" in the field of cutting tools, "CNH" in the field of tractors, airborne technology and "Riegl" measurement technology in the field of surveying technology, "Sapro" for data management for breeding pigs, "Microtronics" with "Lorawan"- technology for frost monitoring in vineyards.

As mentioned in the Lower Austrian Digitalization Strategy, the foundation of pro-actively working to face the challenges coming with Industry 4.0 and Digitalization was laid in Summer 2016 as follows: "The process of drafting a future-oriented mid- to long-term digitalization strategy began in the summer of 2016. The following steps were taken to ensure sustainable development:

- Analysis of current studies and know-how;
- Events for companies, schools and the public, relating to sub-aspects of digitalization such as additive manufacturing, 3D-printing, human-machine interaction, digitalization and qualification, data management and learning from data;
- Founding of the "Technology and Digitalization Unit" in the Department of Economy, Tourism and Technology in the Office of the Lower Austrian Provincial Government;
- Working discussions with seven cross-departmental and theme-specific working groups and initiation of a comprehensive internal administrative process for the further development and implementation of digital applications in administrative processes;
- Establishment of an advisory committee with international experts for exchange and for critical reflection on the digitalization strategy and the implementation of the same".[16]

Main hurdles to become more innovative

An analysis of the digital transformation showed that:

- 1/3 of Lower Austrian companies do not deal with this topic;
- There is a low awareness for the topic itself;
- There is a low participation in national funding programs for R&D on digitalization compared to other Austrian regions.

However, the analysis also showed high interest of companies to collaborate with each other as well as with research and education institutions. Due to the heterogeneous economic structure, differentiated approaches and support offers are necessary.

[16] http://www.noe.gv.at/noe/Topics-in-English/Digitalisierung_Folder_Englisch.pdf, p. 9

Annex 3. Regional status analysis. Slovenia

Main economic figures

The economy of Slovenia is characterized by innovation, work morale and loyalty to businesses. The educational composition of employees at the end of 2018 was as follows: 9.3% of persons in employment had primary education or less, 56.1% had secondary education, and 34.6% had post-secondary education. Good language and ICT skills prevail. High level of digitalization/high ranking on various indexes and received titles confirm that Slovenia is a modern and digitalized country focused on sustainable development. Among 28 Member States, Slovenia ranks 16th in the European Commission Digital Economy and Society Index (DESI) 2019.

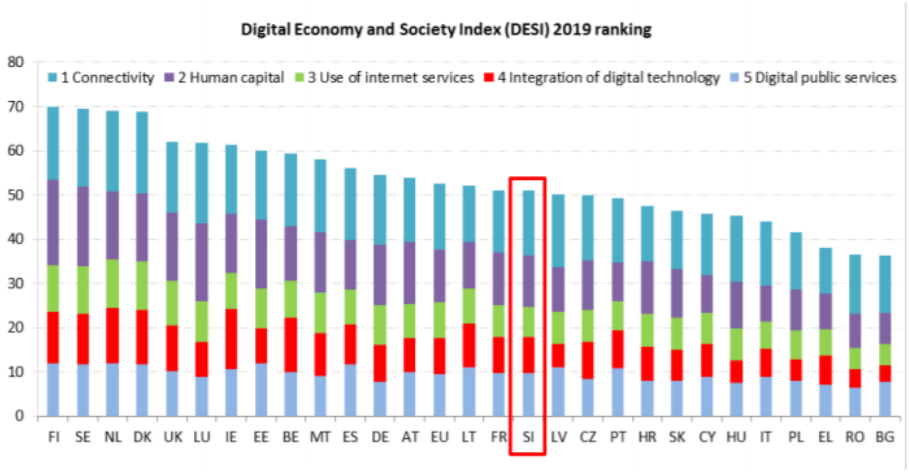

Figure 1. Digital Economy and Society Index 2019, Country Report Slovenia[1]

In March 2019, OECD published the report, which identifies seven policy dimensions (Access, Use, Innovation, Jobs, Society, Trust, and Market openness) that can lead countries to shape the digital transformation in order to improve lives. Each of the identified dimensions includes several indicators, which were measured between the years 2015 and 2018. Slovenia is around the OECD average for most of those indicators, and its position is comparable with neighbouring countries. Nevertheless, there is still a strong potential for advancement taking into consideration several business indicators, especially those related to Innovation.

Considering SMEs, the OECD report indicates four out of seven policy dimensions that should be taken as the most relevant: Use, Innovation, Trust, and Market Openness. The use policy dimension covers the effective use of digital technologies and data. Slovenia is around the OECD average for most of the indicators. It is above the average for the business indicator that assesses the share of small businesses making e-commerce sales in the last 12 months.

[1] https://ec.europa.eu/digital-single-market/en/scoreboard/slovenia

The innovation policy dimension covers several business indicators where Slovenia is quite below the OECD average. Those indicators were assessed in years 2016 and 2017. The share of start-up firms in the business population is the indicator where Slovenia reaches the OECD average. The trust policy dimension covers trust in digital environments. Considering this report, Slovenia is mostly around the OECD average. One indicator considering trust policy dimension for Slovenia is quite low, showing the percentage of Internet users experiencing abuse of personal information or privacy violations. Market openness is another policy dimension. Slovenia is above the average when it comes to the share of businesses making e-commerce sales that sell across borders, but quite below the average for share of predominantly digitally-delivered services in commercial services trade.[2]

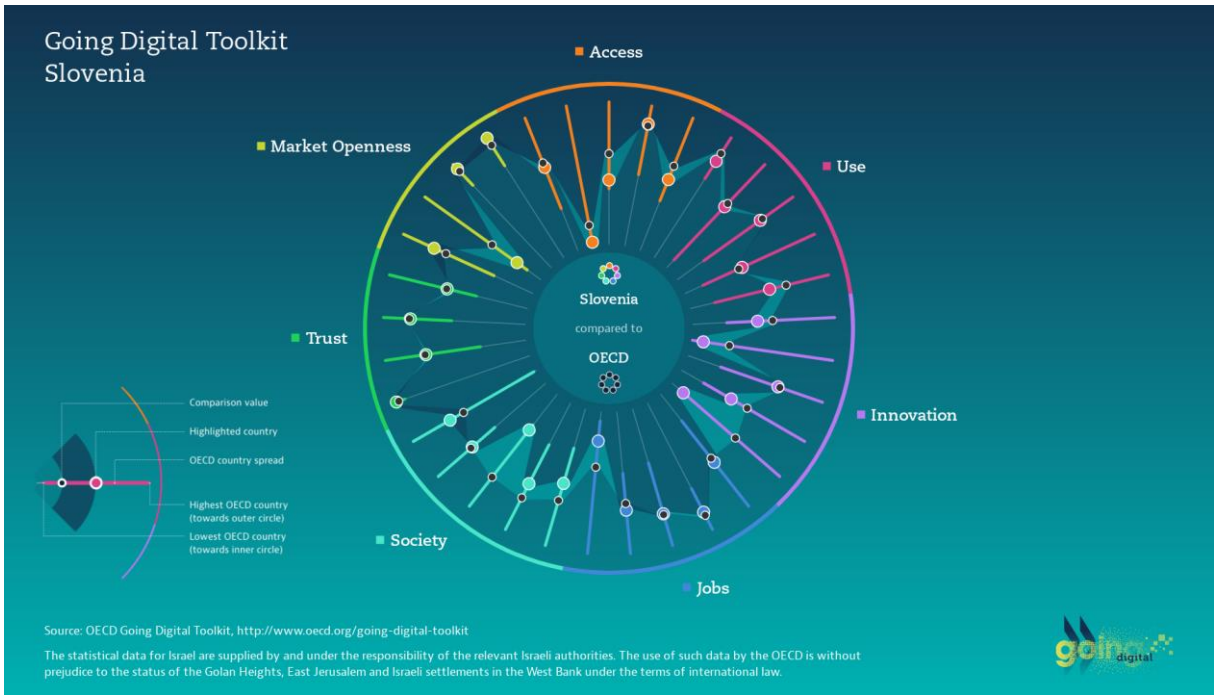

Figure 2. Going Digital Toolkit 2019[3]

The largest share of the Slovenian economy is constituted by service activity. According to statistics, they accounted nearly 64% of the total GDP (includes tourism as an increasingly important service sector). The industrial sector contributes around 26%, construction work 8%, and agriculture 2% to the total GDP. Major Slovene industries produce electrical equipment, electronics, trucks, chemicals, processed food, textiles, paper and paper products, and wood products. Among the main industries in Slovenia are also pharmaceutical and automotive manufacturing. Other major economic sectors include the food industry, electrical devices, metal processing, and chemicals. Meanwhile, tourism is becoming an increasingly important sector. The economy is geared towards services, and Slovenia can boast top-class services in the field of information technology.

[2] OECD. (2019). Going Digital: Shaping Policies, Improving Lives, OECD Publishing, Paris.
[3] https://goingdigital.oecd.org/en/

Green technology and recycling are both promising industries as their development is based on the transition to a circular economy. In Slovenia's green technology sector, a significant number of companies, such as Snaga, Dinos, Gorenje Surovina, Kemis, and more than 50 water-supply and sewage enterprises (municipalities or public utilities) are included. The energy and renewable energy industries are among the fastest-growing industries in the country due to numerous investments. It is comprised of the producers of Slovenian Hydro Power Plant Holding, GEN-i energija, and Heating Power Plant Ljubljana. The most important Slovenian energy trader and, by revenue, the largest Slovenian company is Petrol. Some of the largest Slovenian companies operate in the field of ICT and nanotechnology. During the economic crisis years around 2008, several highly educated young Slovenes entered the industry, triggering its visible growth. The pharmaceutical industry is a traditional export industry consisting of Krka and Lek manufacturers, the wholesale companies Salus and Kemofarmacija, and more than 500 other companies. In total, it generates around EUR 2.0 billion in revenues and EUR 200 million in profits. The chemical industry has been booming in recent years. Larger companies in the industry are Helios and JUB, AquafilSLO, BELINKA PERKEMIJA, Cinkarna Celje, TKI Hrastnik, ECOLAB, HENKEL MARIBOR, JUTEKS, KAMNIK-SCHLENK, MELAMIN, MITOL, PLASTIKA SKAZA, SILVAPRODUKT, SOLCHEM, STRAMEX PET, TANIN SEVNICA, and many others. Slovenia also has some important actors in the construction and housing domain, like Marles, the Slovenian largest manufacturer of prefabricated buildings.

Considering that Slovenia is the second most forested European country, it is understandable that wood processing and furniture industries have developed early in our country. The wood processing industry has been experiencing a new upswing in recent years, mainly because wood remains a key material of the low carbon society of the future.

Parameter	Description
Area of the country	20.273 km^2
Land use	Utilized Agricultural area = 4.814,2 km^2 Forest area = 11.772 km^2 Utilised agricultural area: 23,75% Utilised forest area: 58,07%
Country GDP (2018)	SI =46,6 billion EUR; GDP per capita = 22.563 EUR
Main industries in the country in terms of the level of employment and revenue/turnover	• Steel industry • Automotive manufacturing and supply • Manufacturing of electrical devices • Household appliances • Wood processing industry • Pharmaceutical • Chemical • Construction and housing • Engineering • Textile • Green technology and recycling
Industries in which fiber-based sectors can be involved	• Housing and construction • Furniture • Food processing (food supplements) • Cosmetics

	• Pharmaceuticals • Animal feed • New materials
Percentage of SMEs of the whole economic sector	176.220 MSP (2017) = 99,8%[4]
Percentage of SMEs in the fiber-based sectors of all SME	85%[5]

Table 1. Economic figures[6]

This report is based on desk research done by two regional partners from Slovenia. Elaborated SMEs are members of Strategic Research and Innovation Partnerships (SRIPs) [7] for Sustainable Food Production, Circular Economy, and Wood Industry Cluster Slovenia, which is also a partner in SRIP Smart Buildings and Home with Wood Chain. These three SRIPs already use natural fibers (wood, algae).

SRIP Food

SRIP HRANA is a long-term Strategic Research and Innovation Partnership for Sustainable Food Production. It has developed into a dynamic community of agriculture holdings, companies, cooperatives, research institutions, investors, and other interested parties, whose main interests are focused on the improvement of research and development activities in companies for the purpose of agri-food sector development. Structure-wise, the partnership consists of 454 enterprises (SMEs), 92 cooperatives, 72.377 agricultural holdings, and 704 food processing companies (large enterprises and SMEs). Additionally, partners in SRIP Food are faculties of all three Slovenian universities, research institutes, and others.

SRIP Circular Economy

The Strategic Research and Innovation Partnership – Networks for the transition into circular economy (SRIP – Circular economy) is a connection of Slovenian business subjects, educational and research institutions (RRI), non-governmental organizations and other interested parties, in collaboration with the state, into new value chains according to the economic principles of closed material flows. The included partners are 42 SMEs, 11 large companies, 16 research, and educational institutions.

Wood Industry Cluster Slovenia

The Wood Industry Cluster comprises a third of employees in forestry and wood-processing industry and the most important research institutions in Slovenia. It has 94 member companies and 9 research, knowledge, and policy members. Forestry and wood-processing companies, members of the Cluster, are companies with a rich tradition and are well-known all over

[4] IPMMP – EPF UM_ Slovenski podjetniški observatorij; po podatkih AJPES, 2018a (za leta 2013–2017) (2018).
[5] Estimation based on the number of members (SMEs) of Strategic research and innovation partnership for Sustainable food production, Circular Economy and Wood Industry Cluster Slovenia.
[6] Statistical office of Republic of Slovenia: Skupna in kmetijska zemljišča kmetijskih gospodarstev, Slovenia, po letih (2019). https://pxweb.stat.si/SiStatDb/pxweb/sl/30_Okolje/30_Okolje__15_kmetijstvo_ribistvo__03_kmetijska_gospod__01_15165_zemljisca/15165O1S.px/table/tableViewLayout2/
[7] SMART SPECIALISATION PLATFORM, https://s3platform.jrc.ec.europa.eu/regions/SI

Slovenia. Their product lines cover most of the woodworking products, from sawmill and joinery products to a wide range of furniture. In addition, some companies offer surface coatings, PU foam materials, and energy, too. Most Wood Industry Cluster members are also members of the SRIP on Smart Buildings and Home with Wood Chain. The SRIP is covering Energy refurbishment of buildings, interfaces between smart buildings and smart grids, integrated management systems for buildings, homes and the working environment of the future, and smart appliances for energy efficiency and self-sufficiency of buildings. The R&I activities also include sustainability of buildings with re-use of used construction materials and waste, as well as renewable and eco-friendly and healthy materials, and the integration of wood-chain in the design of homes and working environments of the future by including research and innovation deriving from traditional knowledge and skills in using the wood and wood-compatible natural materials.

Besides SRIPs, another important institution for natural-based fibers is the InnoRenew CoE - Renewable Materials and Healthy Environments Research and Innovation Centre of Excellence. The goal of the InnoRenew CoE is to develop an original treatment solution(s), combine already available technologies into hybrid modifications in order to enhance natural wood properties, and share wood modification techniques that improve targeted wood properties or create functions for wood while reducing the environmental impact of wood use. With the establishment of InnoRenew CoE, Living Lab InnoRenew continued as a public-private-people partnership, offering different activities and services to its members. Currently, Living Lab InnoRenew brings together 107 members from 25 countries, 56 of which are SMEs, 21 are higher or secondary education institutions, and 10 are research organizations. Other members include municipalities, regional development agencies, ministries, business and research associations, technology platforms, and clusters, as well as some interested individuals.

Value chain mapping

For the fiber-based value chains in Slovenia, wood, apples and algae fibers have been selected.

Due to the lack of statistical values in the bioeconomy sector in Slovenia as a whole, fiber harvest data, available industrial applications, and turnover could not be obtained for algae fibers in general. Instead, the required data is obtained through analysis of SRIPs data and includes indicators from Eurostat, RIS (Internet usage in Slovenia), National statistics, and related bioeconomy projects in Slovenia[8,9].

[8] Juvančič, L., Case Study (BERST region): Slovenia, 2015.
[9] Juvančič, L., Erjavec, E. 2014. Study on investment in agricultural research: Review for Slovenia. Country report for EU 7 FP Project: The impact of research on EU agriculture (IMPRESA).

Wood sector

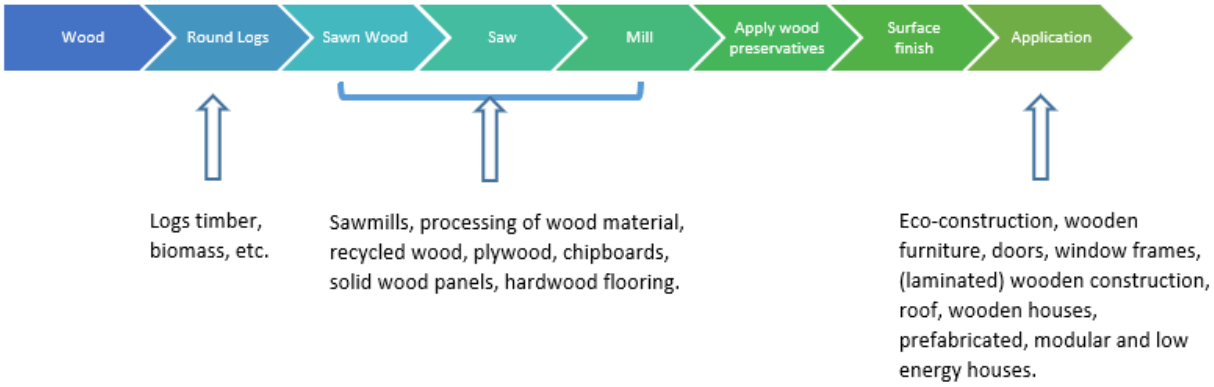

Figure 3. Eco-construction value chain starting from wood as feedstock (Slovenia)[10]

Wood value chain, as one of the Slovenian's key priorities, is well covered in terms of Cluster support and other initiatives. Slovenia achieves major export of unprocessed wood (2,6 million m^3 in 2018), and the export of timber products in 2018 amounted to 51% of the total amount of timber products manufactured. In the same year, timber production in state forests has increased by 32%. For the eco-construction value chain, two entities cover all six segments from wood harvesting and round log handling (wood processing) to surface finishing, advance wood composite manufacturing, and end-products (houses, furniture) (semi- and final products). Throughout our study, we have identified a list of SMEs participating in each eco-construction value chain component, which is presented in Table 1. Despite natural limitations caused by forest compositions, the wood harvesting and timber hauling processes are carried out by using adapted modern machinery by most entities, while taking environmental protection into account. After the initial processing of harvested wood, the resulting timber logs and biomass are used as a resource material for further processing. According to the report published by the Slovenian Forestry Institute, in 2018 the production of logs in state forests amounts to 36% in total amount of logs produced, while the rest of the production of logs derives from private or local community forests. In addition, there has been an increase in selling wood for pulp and round industrial timber production, but also a decrease in the number of logs and firewood sold[11].

Depending on the wood quality criteria (e.g., basic density, visible defects such as cracks, etc.) and log's diameter, length, and shape, logs are sawed into different dimensions, graded according to their wood quality and sent to different processing streams. As an example, logs cut from the lower part of the stem are usually of lower quality, so they can be processed into sawn timber or plywood, whereas logs cut from the upper part of the stem are of better quality, so they are used to produce final products. The sawn timber goes through the milling process, which produces timber of different dimensions and quality. Any by-products, such as bark, sawdust, and chips are used as biomass or raw material for paper industry. In order to prevent

[10] Self-developed by UM-FERI and Anteja ECG, Slovenia. (2019).
[11] WoodChainManager, http://wcm.gozdis.si/strokovni-prispevki/trg-gozdnih-lesnih-sortimentov-v-sloveniji-v-2018

wood degradation caused by external factors (e.g. mold and insects), wood preservatives are applied to the processed timber. Finally, the timber finishing step is carried out to embellish and/or protect the surface. This step includes sanding, scraping, filling surface imperfections, waxing and similar. Once the surface is polished, the final product is used as a resource material in eco-construction, or it can be directly consumed by users (e.g. wooden furniture)[12].

Value chain component	Companies
Round logs production	• Biomasa Jakoša d.o.o. • Pinales d.o.o. • MAX LESS d.o.o. • BoP d.o.o. • LIP opažne plošče Bohinj d.o.o. • Elvipo d.o.o. • HS-LES d.o.o. • Lesgal d.o.o.
Sawing and milling wood	• TISA d.o.o. (biomass production) • Biomasa Jakoša d.o.o. (biomass production) • Mizarstvo Kovač d.o.o. (plywood production) • Alpimex d.o.o. (biomass production, milling) • Amles d.o.o. • Brst d.o.o. (plywood production) • CEMPRIN d.o.o. • CENTERNORMA d.o.o. (plywood production) • Energoles Bohor d.o.o. (plywood production) • I-LES ISKRA d.o.o. (plywood production) • HS-LES d.o.o. (biomass, plywood, chipboards production) • Furnir d.o.o. (plywood production)
Applying wood preservatives	• Amles d.o.o. (wood drying) • HS-LES d.o.o. (wood drying) • Elvipo d.o.o. (wood impregnation) • I-LES ISKRA d.o.o. (wood drying) • MERKSCHA d.o.o. (wood colouring, veneer application)
Surface finishing	• MAX LESS d.o.o. (surface sanding) • I-LES ISKRA d.o.o. (sanding) • HS-LES d.o.o. (sanding, waxing) • Lesgal d.o.o. (sanding)
Application	• LIP Bled d.o.o. (wooden furniture production and installation) • B-F stopnice d.o.o. (wooden stairs) • EVOSTIL d.o.o. (wooden home decorations) • GROLES d.o.o. (wooden floors, facades, fences) • Javor d.o.o. (wooden beams) • EXTRAFORM d.o.o. (formwork beams production) • Javušnik d.o.o. (wooden prefabricated houses) • Lesarstvo Žaže d.o.o. (wooden furniture) • MARLES PIM d.o.o. (wooden prefabricated houses)

Table 2. List of companies participating in the eco-construction value chain

[12] Moore, J. R., & Cown, D. J. (2015). Processing of wood for wood composites. In Wood Composites (pp. 27-45). Woodhead Publishing.

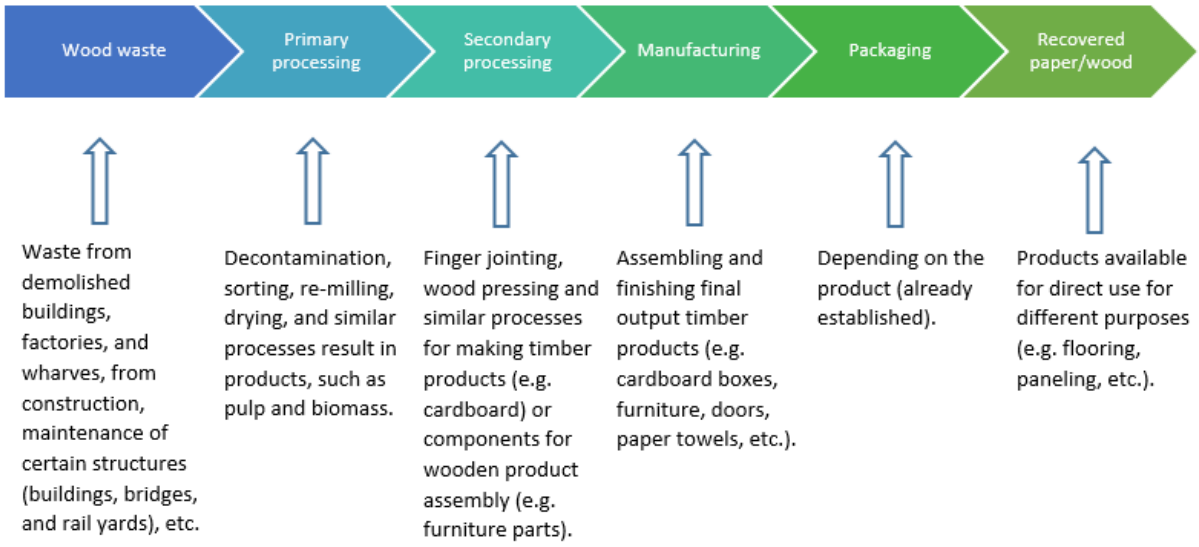

Figure 4. Wood value chain starting from recycling (Slovenia)[13]

According to data from 2016, only 5% of waste wood is recycled in Slovenia, while 62% of that wood is intended for energy production. Compared to other types of waste in Slovenia, wood waste represents only 2% or approximately 148,000 tons of all waste[14]. Most of the wood intended for recycling is obtained from factories, wharves, or from construction, demolition, or maintenance of buildings and structures, such as bridges and railway tracks. A few years ago, the majority of this waste material went to landfills, but today the goal is to maximize the percentage of recycling. The main purpose of recycling is to turn used wood residues back into something useful. In order to achieve this, the wood waste must be treated in several stages. In primary processing, most of the wood waste is first treated by decontamination (e.g. nail removal), sorted by quality, and used accordingly in the re-milling or drying phases[15]. As a result of this phase, pulp and biomass are usually generated. Mostly, only high-quality wood waste is used to enter the second phase. In some cases, it may also be sent directly to the market as raw material. Less quality wood is typically used for energy production. In the secondary processing phase, woodworking techniques such as wood pressing, finger jointing and other related transformation of the input material are used. As an example of the output of this phase are glued panels, cardboards, or components, which are needed for the assembled larger units, with higher added value, in the next phase. During the manufacturing phase, the semi-finished products are finalized, assembled or designed. Examples of such products are cardboard boxes, furniture, paper towels, and others. In the next phase, some of these products are also packaged and ready for transport, depending on the product itself. The final product of the recycling chain is recovered wood, in the form of products intended for various

[13] Self-developed by UM-FERI and Anteja ECG, Slovenia. (2019).
[14] Statistical Office of the Republic of Slovenia. (2017). With statistics against waste generation and improper waste treatment, https://www.stat.si/StatWeb/en/News/Index/7067.
[15] Muthu, S. S. (2015). *Environmental Implications of Recycling and Recycled Products*. https://doi.org/10.1007/978-981-287-643-0_4.

usages (from flooring, paneling to furnishing and home decoration)[16]. Slovenian companies that are part of this value chain are listed in Table 3.

Value chain component	Companies
Primary processing	• Tisa d.o.o. (sorting, milling and processing of wood waste into biomass or wood chips) • Surovina (sorting and processing of wood) • ABC Les (wood milling) • HS-LES d.o.o. (wood drying) • Alpimex d.o.o. (biomass production and milling) • Lesgal d.o.o. (biomass production and milling)
Secondary processing	• Mizarstvo Kovač (wood pressing) • LESONIT d.o.o. (chipboard and panels production, CPL laminates)
Manufacturing	• Urban DESIGN Group (production of unique furniture) • Ozara d.o.o., (production of various small recycled wood products such as magnets, wooden paintings, pendants, etc.) • Silvaventus d.o.o. (production of doors, windows, floors, furniture) • J.u.A. Frischeis d.o.o. (WPC flooring)
Packaging	• JE-EMB d.o.o. (recycling of wooden packaging)
Recovered paper/wood	• ProAmbient d.o.o. (sale of parquet made from recycled wood)

Table 3. List of companies participating in the recycled wood value chain

Agriculture

In the food processing sector, higher amounts of waste are obtained from fruits and vegetables industries. This waste generally includes peels, rind, seeds, core, rag, stones, pods, vine, shell, skin, pomace, etc. The waste represents renewable raw material and the by-products obtained from fruits and vegetables waste could have much higher value than the original raw material, which is now traditionally used for composting or biogas. Fruits and vegetables waste is rich with different bioactive components and it can be utilized for the recovery of valuable compounds. Hence, it is leading to the zero-waste concept, which allows effective valorization of the generated agro-industrial waste to value-added products, which have several applications in the food sector (e.g. colouring agents, anti-oxidative agents, preservatives) or it can be processed to pet food or fertilizers. In Slovenia, besides grapes, apples are being produced at most. However, in the production of apple juice, there are many residues (apple pomace) that can be used for distilling spirits or they can be composted or converted into bio-gas.

In processing of juices, pulp, frozen products, etc., water is also used for washing fruits. This industrial wastewater can be further used for algae cultivation.

[16] Man Without Country. (2019). Why Recycle Wood Waste? https://www.manwithoutcountry.com/the-importance-of-recycling-wood-waste/

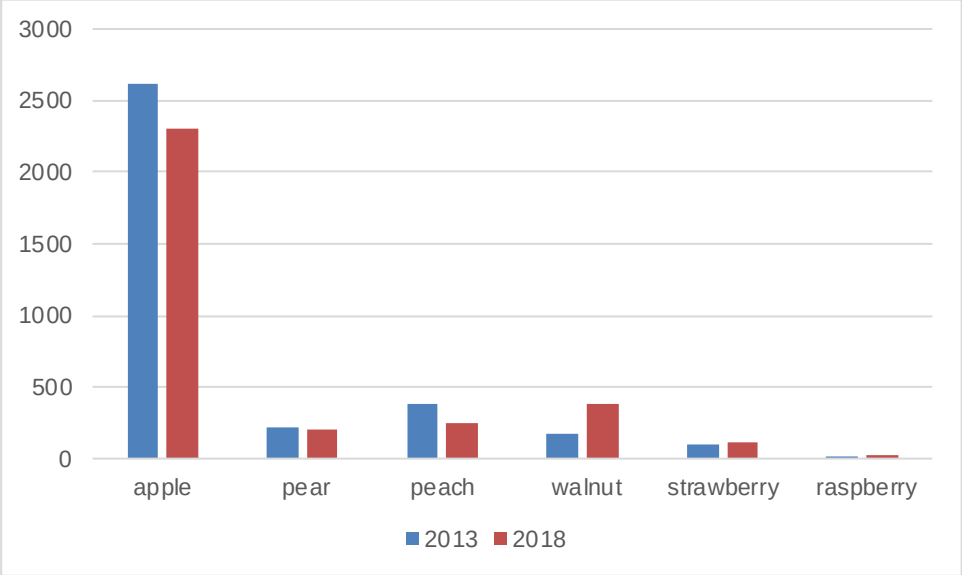

Figure 5. Fruit growing in Slovenia[17]

In 2018, the production of apples was 86.587 tones. In Slovenia, most companies out of 169 with NACE C10.3.2 - Manufacture of fruit and vegetable juice are micro- or small-sized companies, or they are registered as complementary farm activities.

The agro-food sector is the most appropriate sector for the implementation of circular economy model by recycling its by-products, thereby creating added value with fewer resources.

The biotechnology of microalgae has gained considerable importance in recent decades. Applications range from the production of food supplements, animal feed, and live feed in aquaculture, to valuable products for pharmaceutical and ecological applications. Also, exploitation of microalgae for bioenergy generation or combined applications for biofuels and CO2-mitigation, by which CO2 is captured and sequestered, is under research. For most of the applications, the market is still developing, and the biotechnological use of microalgae will extend to new areas. Considering the enormous biodiversity of microalgae and developments in genetic engineering, this group of organisms represents one of the most promising sources for new products and applications[18]. In this field, some "newcomer" SMEs in Slovenia have found their market niche. One of the preconditions for algae installations is the location with a lot of sun or light, and that is why Slovenia is more appropriate. Algae are a natural raw material that for cultivation does not require agricultural land. As food waste rises on the sustainability agenda, more food companies and retailers will make waste reduction pledges. Food by-products will receive greater recognition as raw material and become a source of new products.

[17] Statistical office of Republic of Slovenia
[18] AlgEn, algal technology centre (2019), Applications. https://algen.eu/node/95.

Algae biomass is a valuable resource in the European bio-based economy currently used mainly by the food and chemical industry[19]. This resulted in relatively large amounts of EU funding that have been devoted to algae demo projects over the last decade, and some demonstration project in Slovenia prove the technical and economic feasibility of using algae for wastewater treatments. In 2017, 217.7 million m3 of wastewater of various origins were discharged from public sewage in Slovenia: 6% of wastewater came from industrial activities, 9% from other activities, 27% from households, 58% wastewater was other wastewater (precipitation water, backwater, sea invasions, etc.). According to the bibliographic references consulted in this study, about 472 tons dry weight of macroalgae were commercialized in Europe in 2013 from which a quarter was supplied by European producers[20].

Microalgae biomass production in Europe includes several species, which are commercialized as raw biomass to be used for research or cultivation purposes, or processed in several applications such as food (human nutrition), aquaculture feed, cosmetics, and pharmaceuticals. Over the last decade, the demand for algae biomass has increased due to the development of new algae biomass-based applications (feed and food supplements, nutraceuticals, pharmaceuticals, third-generation biofuel, and bioremediation)[21]. The amount of biomass produced is low, but the commercial value of some species and applications is high (e.g., some species such as Haematococcus Pluvialis are being sold at a value of €125/ml).

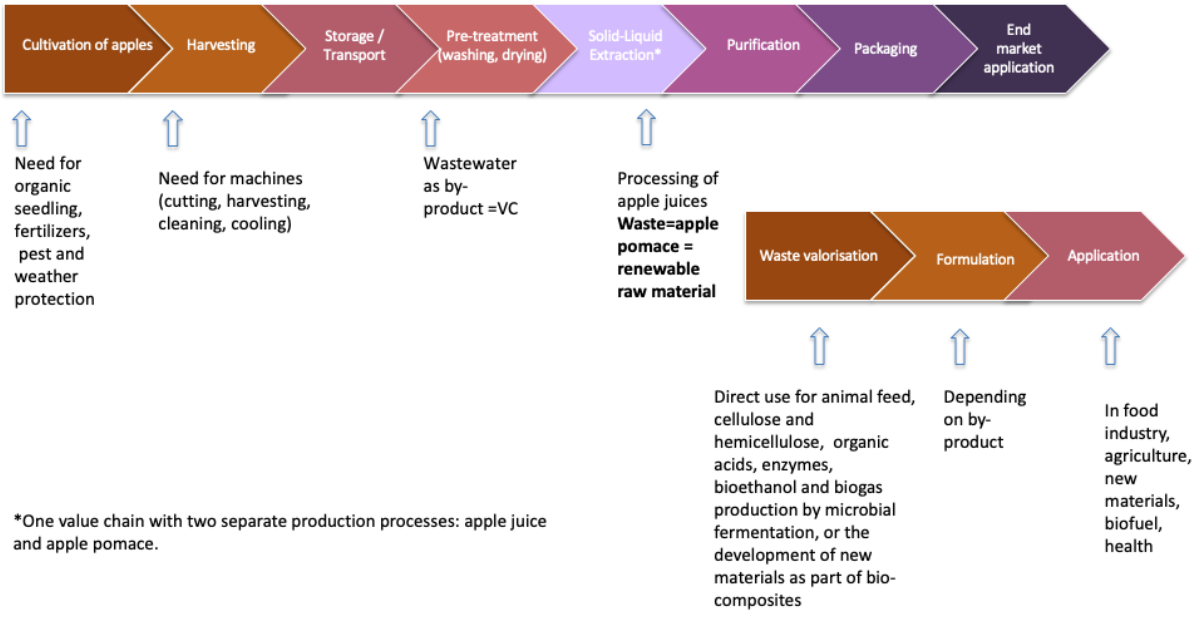

Figure 6. Value chain starting from recycling of apple waste (Slovenia)[22]

[19] Enzing, C., Ploeg, M., Barbosa, M., & Sijtsma, L. (2014). Microalgae-based products for the food and feed sector: an outlook for Europe. JRC Scientific and policy reports, 19-37.
[20] AEBIOM. 2017. European Biomass Association. Statistical report. European bioenergy outlook. Key findings, pp. 1-43.
[21] García, J. L., de Vicente, M., & Galán, B. (2017). Microalgae, old sustainable food and fashion nutraceuticals. Microbial biotechnology, 10(5), 1017-1024.
[22] Self-developed by UM-FERI and Anteja ECG, Slovenia. (2019).

The by-product in the production of apple juices is apple pomace (comprising of pulp, skin, seeds, and stalks). Examples of SMEs that produce juices are beverage/juice producers, where also the waste/pomace is generated. The apple pomace can be (like traditionally) used for composting and soil production (gardening, recycling companies) and for bio-gas production. Due to the high nutrients and organic matter, the pomace can be used as raw new material for animal feed production, cellulose, organic acids, enzymes, etc. For these products with high value added, the production exists abroad.

Value chain component	Companies
Cultivation of apples	• Mirosad • Evrosad • Sadjarstvo Slom • Bio dan
Harvesting	• Evrosad • Mirosad
Storage / Transport	• Hladilnica Bohova • Kmetijske zadruge
Pre-treatment (washing, drying)	• Fructal • Dana • Vipi • Algen d.o.o. (wastewater)
Solid liquid extraction, purification, packaging, end market application	• Fructal • Dana • Vipi
Waste valorisation	• Panvita proizvodnja krme (animal feed)
Formulation	• Panvita proizvodnja krme
Application	• Koto (pet feed) • Žito • PP - AGRO d.o.o.

Table 4. List of companies participating in the apple fruits expanded value chain

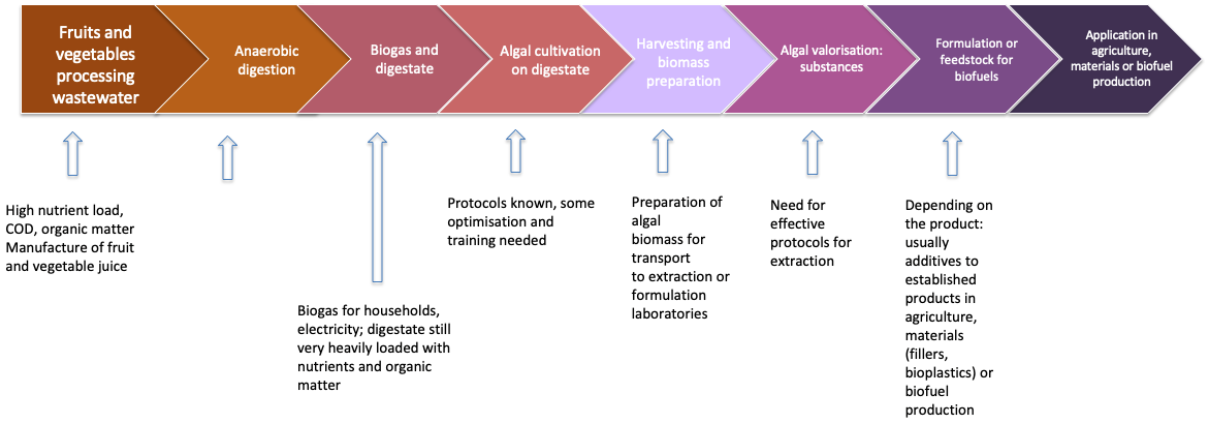

Figure 7. Value chain for algae production from wastewater (Slovenia)[23]

[23] Self-developed by UM-FERI and Anteja ECG, Slovenia. (2019).

The source of "food" for algae production are by-products of food production, such as whey, fruit residue, water from cooking vegetables and similar, but not mixed with municipal water (from a toilet, cleaning of packaging, etc.). Examples of SMEs that produce food for algae as by-product are beverage producers, breweries, dairies, vegetable producers. For the algae growers, a specialized company can be used and eventually the ponds are or can be owned by companies themselves. Users of algae and algae raw materials (lipids, proteins, pigments) could be the food processing industry, juice producers, salt pans (include spirulina in their products), as well as dairy products, pet products, livestock products.

Value chain component	Companies
Fruits and vegetables processing wastewater	• Fructal • Dana • Vipi
Anaerobic digestion	• Fructal • Dana • Vipi
Biogas and digestate	• Panvita Ekoteh
Algal cultivation on digestate	• Fructal • Dana • Vipi • Algen d.o.o. (wastewater)
Harvesting and biomass preparation	• Algen d.o.o.
Algal valorisation: substances	• Panvita proizvodnja krme (animal feed)
Formulation or feedstock for biofuels	• Panvita Ekoteh
Application in agriculture, materials or biofuel production	• Koto (pet feed) • Žito • PP - AGRO d.o.o. • Panvita proizvodnja krme (animal feed)

Table 5. List of companies participating in the algae biological waste value chain

Digitalization knowledge ecosystem

The digitalization is an emerging topic in Slovenia. Aspects of the digitalization are entering different business domains and becoming a part of everyday work, also of the SMEs. The digitalization level in Slovenia is measured using different indicators and indexes. As within the EU, the digitalization level of the economy is measured with the Digital Economy and Society Index (DESI). The DESI for Slovenia in 2019 is 50,9, ranking on the 16th place out of the 28 EU members. The score of Slovenia in 2018 was 47,9, ranking in 15th place, and in 2017 45,1, ranking in 16th place. Although Slovenia scored better in 2019 than in 2018, it still lost one place in the ranking due to the overall increase of DESI within EU. Within the DESI, the fourth

dimension, Integration of digital technology indicates the digitalization of business. Slovenia scored 40,1 in 2019 and ranked in 15th place among EU members. The score increased in comparison to 2018, when it was 39,5 and from 2017 when it was 37. As emphasized in the report, the degree of digital technologies used by business actors differs from sector to sector. Within DESI 2019, 30% of Slovenian enterprises use electronic information sharing, 18% use social media, 10% work with big data and 17% use cloud services. The latter advanced from 2017 when the percentage was 13%. The part of the indicator also looked into the SMEs selling online and selling online cross-border. Aligned with the EU average, 17% of Slovenian SMEs sell online, wherein the number increased from 2017 when it was 13%. In addition, 12% of SMEs sell online, exceeding the EU average of 8%.[24] Another index used for measuring digitalization level within Slovenian enterprises is the Digital Intensity Index (DII). The index is calculated based on 12 indicators used to monitor ICT usage in enterprises. In 2018, 42% of enterprises in Slovenia had a low, 32% a very low, 23% a high and 3% a very high digital intensity index.[25]

The SMEs can access digitalization knowledge in Slovenia through different paths. Technology parks, university incubators, grants, innovation vouchers, tax incentives, and supportive coaching services address the Small Business Act (SBA) recommendations in the skills & innovation area[26]. SPIRIT Slovenia launched the first call for tender for incentives for digitalization of SMEs in September 2017, and incentives to promote digitalization in SMEs were awarded to 97 SMEs in 2017. Also, the Chamber of Commerce and Industry of Slovenia (CCIS) offers the Digital Academy to raising awareness of the importance of digital transformation in SMEs. As a result of the Digital Slovenia 2020 strategic framework, the Slovenian Digital Coalition - digitalna.si has been established at the 11th Slovenia Business Summit on 24th November 2016, which aims to assist companies and individual actors in implementing the strategy and ease the collaboration between stakeholders (industry, research, civil society, public sector and others)[27]. In 2018, the Digital Innovation Hub Slovenia (DIH Slovenia) was established. Initial partners come from the specialization platform Strategic Research and Innovation Partnerships (SRIP), the industry, the national FabLab network, universities, the CCIS and the Ljubljana Technology Park. DIH Slovenia offers different catalogues covering trainings and consulting options. Also, six market specific DIHs were established: DIH AGRIFOOD, DIH Eastern Slovenia, DIH HPC, DIH Styran Technology Park, DIH for Smart Manufacturing, and DIH University of Maribor. SRIPs, as the individual institutions, helps Slovenian stakeholders to pool investment and intellectual potentials and help them in setting up a comprehensive innovation ecosystem with the aim of entering global markets and improving their position in priority areas. SRIP was created for each of the priority domains from the Slovenian Smart Specialisations Strategy: SRIP Smart Cities and Communities, SRIP Factories of the Future, SRIP Mobility, SRIP Sustainable Tourism, SRIP

[24] European Commission. (2019). Digital Economy and Society Index (DESI), 2019 Country Report Slovenia. Retrieved October 2, 2019, from https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=59912.
[25] Statistical Office of the Republic of Slovenia. (2018). The rate of digitization of enterprises with at least 10 persons employed in 2018. Retrieved October 10, 2019, from https://www.stat.si/StatWeb/News/Index/7812.
[26] European Commission. (2018). 2018 SBA Fact Sheet Slovenia. Retrieved October 10, 2019, from https://ec.europa.eu/docsroom/documents/32581/attachments/26/translations/en/renditions/native.
[27] Digital Slovenia. (2019). Digital Coalition. Retrieved October 8, 2019, from http://www.digitalna.si/digital-coalition-.html.

Smart buildings and Home with Wood Chain, SRIP Circular Economy, SRIP Food, SRIP Health, SRIP Materials. Another project facilitating the digitalization of SMEs is the FabLab Network Slovenia, consisting of 28 FabLabs. The network aims to recognize and use the entrepreneurial potential of local communities in Slovenia[28].

Main drivers for innovation in digitalization

There are a variety of initiatives, and research centers (hubs) started in collaboration with companies (mentioned in the previous bullet point). Some of the thematic areas include distributed systems development, smart factory, machine vision, blockchain, digital innovation learning, etc.[29] Companies encourage the usage of Internet of Things (IoT) and wearables in agriculture for smarter decisions. Additionally, there are projects focusing on smart villages, i.e., developing technologies for biomass processing and development of new biological materials, using secondary raw materials and re-using waste, as well as exploring advanced building materials and products (including wood and wood composites).[30] Smart agriculture initiative is applied in domains such as smart greenhouses (growing plants in controlled environment, horticultural automation systems with agricultural robots), precision farming (e.g., AgroIT project as a platform designed to help farmers to reduce costs without affecting the production, using nanotechnology for increasing crops, etc.), precision livestock monitoring, etc.[31] Digital hubs build multi-sector partnerships between companies, universities, research institutions, and others, which drive digital innovations[32].

Political framework

The Government of Slovenia in 2016 adopted a strategic document related to the development of information society until 2020: Digital Slovenia 2020 – Development Strategy for the Information Society until 2020[33]. Also, the connected documents, Next-Generation Broadband Network Development Plan to 2020, and Cyber Security Strategy were adopted. Digital Slovenia 2020 presents a commitment for acceleration of development of the digital society[34]. In addition, Slovenia adopted Smart Specialization Strategy (S4) 2014-2020, which implements a platform aiming to increase development investments in areas with critical lack of knowledge and capacity, as well as innovation potential. Among others, the strategy addresses policies related to rural development. In this context, one of the addressed priority areas for future investments is "National and traditional resources for the future," in which the

[28] European Commission. (2019). Digital Economy and Society Index (DESI), 2019 Country Report Slovenia. Retrieved October 2, 2019, from https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=59912.
[29] University of Ljubljana. (2019). First demonstration smart factory opened in Slovenia. Retrieved October 10, 2019, from https://www.uni-lj.si/news/news/2019061014161749/.
[30] European Commission. (2018). European Commission supports call for a smarter future for rural areas. Retrieved October 10, 2019, from https://ec.europa.eu/info/news/european-commission-supports-call-smarter-future-rural-areas-2018-apr-13_en.
[31] European Regional Development Fund. (2019). Smart digital transformation of villages in the Alpine Space. https://www.alpine-space.eu/projects/smartvillages/en/test-areas.
[32] Digital Innovation Hub Slovenia. (2019). Digital strategy. https://dihslovenia.si/smernice/digitalne-strategije/.
[33] https://www.gov.si/assets/ministrstva/MJU/DI/7df0f756bc/Strategija-razvoja-ID.pdf
[34] European Commission. (2018). Slovenia: Slovenian Digital Coalition. https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Slovenia_FINAL.pdf.

progress of areas depending on the use of natural and traditional resources (e.g. crafts) is discussed. One of the activities planned to improve this area is developing networks for the transition to circular economy. The objective of the activity is to "connect stakeholders (business entities, educational and research system, non-governmental organizations, the state, and individuals) according to the principle "economy of closed material cycles" into value chains to develop new business models for the transition to a circular economy".[35]

Funding schemes for digitalization of SMEs

The Slovene Enterprise Fund (SEF) is a public financial fund established to provide support and access to funding for SMEs[36]. The Fund continuously publishes calls for funding. It also offers financial products in various forms, such as start-up grants for establishing an enterprise, microcredits for target groups, seed capital (investments) for entering the market, etc. For example, SMEs can receive grants ranging from 250.000 to 2.000.00 EUR for woodworking, or up to 100.000 EUR for their digital transformation[37]. In 2019, Digital Innovation Hub (DIH) Slovenia and Ministry of Economic Development and Technology announced "digital vouchers" for SMEs as a free support to companies, which apply for SEF's public calls related to the preparation of a digital strategy and raising digital competences. Among several voucher categories, "digital vouchers" are awarded to companies for increasing their level of digital competences through employees' digital skills level, so each company can receive between 600,00 and 9.999,99 EUR per employee[38]. One of the more important preconditions to apply for the voucher is to include at least 20% of employees into the training/education process, and the training process can be carried out only by certified organizations registered at DIH Slovenia. Furthermore, it is also possible to receive a voucher for preparing the company's digitalization strategy during the company's digital transformation to cover expenses generated during the entire process (amount ranges between 1.000,00 and 9.999,99 EUR[39]). Before applying, the company must receive a positive grade by DIH (based on the evaluation of current state of digitalization in the company, as well as future digitalization plans) and carefully prepare all the documentation including precise digital transformation plans (note that there should be no previous digitalization strategy developed in the company). As an example, in 2019, Slovenian SME company GeoEnergetika d.o.o. has been awarded a series of grants for research and development projects by the Ministry, a voucher for the preparation of a digital strategy and digital marketing by the Slovenian Enterprise Fund[40]. In total, a Slovenian SME can receive up to 30.000,00 EUR per year through the "digital voucher" mechanism. In 2019, SMEs in Slovenia have received 12,3 Mio. EUR through different incentives aimed at their

[35] Horizon 2020 Policy Support Facility. (2015). Slovenia's smart specialisation strategy. (September), 100–130. https://doi.org/10.4018/978-1-5225-6152-1.ch005.
[36] Slovenski podjetniški sklad. (2019). Javni razpisi in pozivi. https://podjetniskisklad.si/sl/razpisi.
[37] Slovene Enterprise Fund. (2019). About us. https://podjetniskisklad.si/en/about-us.
[38] Slovenski Podjetniški Sklad. (2019). Vavčer za dvig digitalnih kompetenc. https://podjetniskisklad.si/sl/produkti-sklada/sps-dvojcekdpora-pri-produktih/vavcerski-sistemi/vavcer-za-dvig-digitalnih-kompetenc.
[39] SPIRIT Podjetniški Portal. (2019). Vavčerji – finančne spodbude za podjetja za različne namene. https://www.podjetniski-portal.si/novice/vavcerji-financne-spodbude-za-podjetja-za-razlicne-namene-2019-09-09.
[40] Geolux. (2019). Co-financing. https://www.geolux.si/en/co-financing.

digitalization, whereby more than 30.000,00 EUR of government funds has been received for digital transformation of SMEs[41].

Measurement of the digitalization level

One of the most widely used indicators to measure the level of digitalization is the Digital Economy and Society Index (DESI) measured by the European Commission. DESI assesses the country in six domains: connectivity, human capital/digital skills, use of internet services by citizens, integration of digital technology by business, digital public services, and research and development of ICT[42]. The Digital Technology Integration Index (DTII) is a measure partially based on DESI, which measures eight indicators related to changes in the digital transformation of businesses. Furthermore, the Digital Intensity Index (DII) is a Slovenian micro-based index used to measure the company-level availability of 12 digital technologies (e.g. internet for at least 50% of employees)[43]. Other important measurement indexes are the Digital Evolution Index and Digital Transformation Scoreboard[44].

Future digital innovation potential

The Slovenian government has focused its digitalization efforts on establishing a secure broadband connection and a secure cyber-security network that covers the entire territory of the country, including rural areas, and is expected to be completed in 2020. The overall goals for the future are to create a more attractive and efficient lifestyle by combining digital and natural. In the economic sector, the purpose is to promote the emergence of more and more cleantech startups, engaged in sustainable, in-country movement and startups developing water supply systems in the city[45]. Technology focus is expected in the areas of IoT, Big Data, Cloud Computing, and mobile technologies. Activities will focus on digitizing entrepreneurship and business as well as building smart cities and homes. The main objective is to improve the digital skills of individuals and to inspire young generations to choose ICT professions and to provide them with appropriate training for new digital services[46]. Under the Slovenian Digital Coalition, the non-profit association Blockchain Think Tank was formed, focusing on integrating Slovenian knowledge in the field of blockchain, developing test and production environments, drafting legal and other proposals, increasing the number of educational events, creating a global blockchain hub in Slovenia, networking with similar think tanks in other fields and raising awareness of Industry 4.0. Think Tank's main principles for the future are

[41] Meterc, I. (2019). SME support in Slovenia. SPIRIT Slovenia. https://www.gzs.si/Portals/SN-cemp/SME%20support%20in%20Slovenia_11.3.2019.pdf.
[42] European Commission. (2019). The Digital Economy and Society Index (DESI). https://ec.europa.eu/digital-single-market/en/desi.
[43] European Commission. (2017). Integration of Digital Technology. https://ec.europa.eu/newsroom/document.cfm?doc_id=44392.
[44] Vidmar, D., Lenart, G., Pucihar, A., & Marolt, M. (2018, June 21). Stanje digitalne preobrazbe v slovenskih podjetjih. 1133–1147. https://doi.org/10.18690/978-961-286-146-9.91.
[45] Davison, T. (2018). Slovenia Aims to Become a Pioneer of Europe's Green Technology Future. https://150sec.com/slovenia-green-technology/9599/.
[46] European Commission. (2018). Slovenia: Slovenian Digital Coalition. https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Slovenia_FINAL.pdf.

knowledge sharing, transparency, and openness to all stakeholders[47]. In the future, DIH (Digital Innovation Hub) Slovenia strives for the development of services for the digital transformation of the economy, education and public administration, development of digital competences, promotion of innovations, creation of new business models, and access to experiment and pilot environments[48]. Business expenditure on research and development in the information industry, patents from the ICT field, ICT investment and support for digitalization projects in Slovenian language are also highlighted as aspects for great innovative potential[49].

Main hurdles to become more innovative

In Slovenia, there is still a wide gap between coverage by broadband between cities and the countryside. In 2016, 40% of rural households had access to high-speed broadband, while the percentage of urban households was 75%[50]. According to DESI, in 2019, Slovenia scored 46,6 in the domain covering the use of internet, placing the country on 21st place among the EU members. The score in had grown from 2017 when it was 39,9[51]. Although the field of digital literacy in Slovenia is below the EU average, Slovenia scored comparably to its neighbors (the score of Italy is 40,4, Hungary scored 42,1, Croatia 49,7, and Austria 51.5). 54% of the population has at least basic digital skills and 30% of Slovenia's population have above basic digital skills. In addition, Slovenia is a small country, with a consequently small market, with smaller companies that do not have as many assets as large ones[52]. At the 1st Forum of the Slovenian Digital Coalition, poor information infrastructure and the problem of legislation, from the segment of personal data protection to regulation, was highlighted as a major problem for the development of digital innovation. The growth of digital technologies is overtaking legislators, and as a result, legal gaps are emerging[53]. There is also a lack of awareness of the importance and potential of ICT for the development of society. In the strategic documents' ICT is not sufficiently recognized as a driver of overall development and economic growth. There is also a lack of stakeholder involvement in designing and implementing measures to promote the development of the digital society. Many regulations represent an obstacle to capture, store and access to digital content. In Slovenia, there is a small number of high-tech companies, a lack of focus on global markets, a low level of early entrepreneurial activity, and a lack of adaptation of incentive measures to the specificities of ICT[54]. Slovenia is also below the average of the share of digital services in commercial services trade, the share of

[47] Digital Slovenia. (2017). Inaugural meeting of Blockchain Think Tank Slovenia. http://www.digitalna.si/inaugural-meeting-of-blockchain-think-tank-slovenia-19-12-2017.html.
[48] Digital Slovenia. (2018). We need a digital revolution in Slovenia. https://dihslovenia.si/en/we-need-a-digital-revolution-in-slovenia/.
[49] Digital Slovenia. (2017). Visoka cena zaradi manka digitalnih kompetenc - Digitalna Slovenija. http://www.digitalna.si/-visoka-cena-zaradi-manka-digitalnih-kompetenc-06-07-2017.html.
[50] European Commission. (2018). European Commission supports call for a smarter future for rural areas. https://ec.europa.eu/info/news/european-commission-supports-call-smarter-future-rural-areas-2018-apr-13_en.
[51] European Commission. (2019). Digital Economy and Society Index (DESI), 2019 Country Report Slovenia. https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=59912.
[52] Digital Slovenia. (2018). We need a digital revolution in Slovenia. https://dihslovenia.si/en/we-need-a-digital-revolution-in-slovenia/.
[53] Digital Slovenia. (2017). Visoka cena zaradi manka digitalnih kompetenc - Digitalna Slovenija. http://www.digitalna.si/-visoka-cena-zaradi-manka-digitalnih-kompetenc-06-07-2017.html.
[54] Digital Slovenia. (2016). Digital Slovenia 2020 – Development Strategy for the Information Society until 2020. https://www.gov.si/assets/ministrstva/MJU/DI/7df0f756bc/Strategija-razvoja-ID.pdf.

enterprises with broadband speed of 30 Mbps or more (7,6% below the OECD average), and below the OECD average based on the number of M2M SIM cards per 100 inhabitants[55].

[55] OECD. (2019). Going Digital: Shaping Policies, Improving Lives, OECD Publishing, Paris. https://doi.org/10.1787/9789264312012-en.

Annex 4. Regional status analysis. Autonomous Province of Trento (Trentino)

Main economic figures

Trentino Region has a surface of 6.207 km^2 and 70% of its territory is situated over 1000m above sea level. The population is about 541.098 inhabitants. The total area of the province is 614.500 ha, 53,4% is covered by woodland areas, 31,2% natural ranges, 9,8% cultivable area and 2% are urban areas. Forests have an estimated stored volume of 63 million of cubic meters (diameters more than 17,5 cm) but this value can overcome 100 million of cubic meters if we consider trees with lower tree diameter (up to 4,5 cm), as in the National Forest Inventory. The forest area is also increasing at a rate of about 0,1% each year. Rivers and lakes area is about 1,7%. The digital infrastructure covers over 800 km of fibre-optic network and over 700 wireless access points (infrastructures and services area is approximately 1,3%). The percentage of land use in industrial and commercial area is 0,4% while the abandoned land, dumbs and mining areas are about 0,2%[1].

The province has GDP of 19.5bE (current price in 2017) with a per capita GDP of 36,1 euro (current price in 2017) (last available data-ISPAT). First economic sector in Trentino is the service industry with about 23.600 active enterprises[2] and about 12.800[3] mln euro of added value and about 169.000[4] internal workers in total. Industry represents the second productive sector with an added value of 4.087 mln euro, 10.851 enterprises and 58.685 internal workers (ISPAT 2016). Traditional sectors include metallurgy and precision mechanic, wood and furniture industry, chemistry, coke, rubber and plastics, food and beverage. Mechatronics in an emerging sector with 300 enterprises and 11.000 workers. The primary sector (farming, forestry and fishing) is characterised by an added value at basic prices of 648,23 mln euro with more than 9.000 workers and 12.019 active companies registered at the Chamber of Commerce. Percentage of SMEs in the whole economic sector is 88-89%.

Industries in which fibre-based sectors are involved:

- Agrifood and waste: Last available statistics[5] show a distribution of agricultural land use: about 110.000 ha for pastures and grazing land; 22.000 ha for tree and shrub crop growers; 3.000 ha for arable land. Concerning livestock activities, cattle breeding

[1] AutonomousProvince of Trento – Urban planning service http://www.statweb.provincia.tn.it/annuario/
[2] ISPAT- Statistic Institution of Trento Province and Unioncamere
http://www.statweb.provincia.tn.it/PubblicazioniHTML/Annuari%20e%20altre%20pubblicazioni%20di%20carattere%20generale/Conoscere%20il%20Trentino/Conoscere%20il%20Trentino%202018/capitolo06/t06_006.html
[3] ISPAT - Statistic Institution of Trento Province
http://www.statweb.provincia.tn.it/PubblicazioniHTML/Annuari%20e%20altre%20pubblicazioni%20di%20carattere%20generale/Conoscere%20il%20Trentino/Conoscere%20il%20Trentino%202018/capitolo06/t06_003.html
[4] ISPAT - Statistic Institution of Trento Province
http://www.statweb.provincia.tn.it/PubblicazioniHTML/Annuari%20e%20altre%20pubblicazioni%20di%20carattere%20generale/Conoscere%20il%20Trentino/Conoscere%20il%20Trentino%202018/capitolo07/t07_001.html
[5] ISPAT - Statistic Institution of Trento Province: Professional agriculture in Trentino. (2014).

accounts for about 45.000 head of livestock; sheep are about 27.000; caprine and pork are about 5.000 each and equine are about 3.000. Grapes and apples are the most important plants cultivated in Trentino. The residues deriving from the processing of grapes could be a valuable source for high value chains. Apple cultivation is the second important agricultural sector in Trentino. The lower quality fruit production is addressed to juice industry, vinegar industry and zootechnical sector.

- Wood for building: Trentino region promotes the use of wood for sustainable construction sector and energy efficiency. Fibre-based materials in the construction sector represent a valid alternative to classic material used in the industry, for example for insulating panels.
- Biotechnology and crop protection products: There are some laboratories specialized in extraction of natural compounds mainly for cosmetics. For example, grape waste is used in cosmetic laboratories.
- Livestock: There are various small livestock farms in Trentino. They produce sheep wool or llama wool, which is then used usually by the very same farm to obtain natural yarn. With the yarn produced, some farms also make fabrics for clothing and homeware.
- Biomass for bioenergy: A big amount of residual biomass from forestry, agricultural cultivation and first-stage wood processing is employed for energy production. 84% on average of the annual harvest in the region is destined to supply the wood industry value chain while the rest is used as firewood by local communities. The main part of wood industry residuals is actually chipped and used for bioenergy and sometimes as mulching and bedding for cattle.

Value chain mapping

Agriculture

In Trentino there is no plant that is used to the largest extent in fibre-based value chains: it is hard to find some fibre production that includes harvesting, industrial application and has outcomes on the market. There is though one observable value chain that concerns the textile industry.

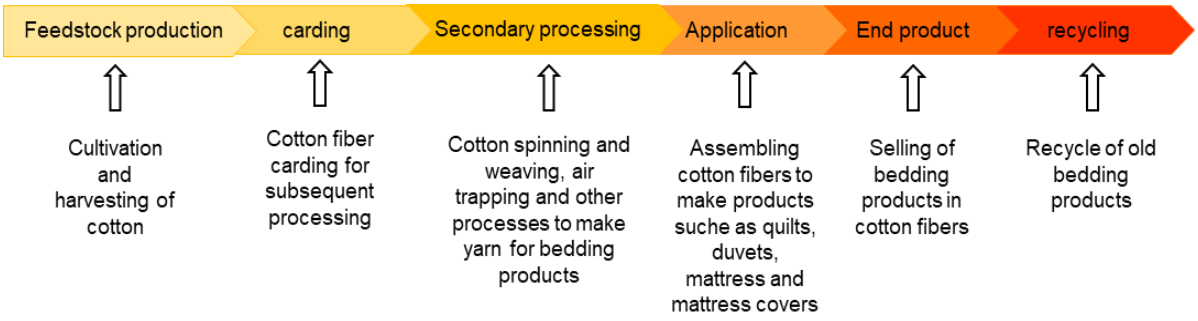

Figure 1. Value chain for textile industry (Trento, Italy)[6]

[6] Self-developed by Hub Innovatione Trentino – Fondazione and Autonomous Province of Trento – Department for Economic Development, Research and Labour. (2019).

There are in fact some companies using and processing cotton fibre as a textile fibre to fabricate quilts, duvets, mattresses and mattress covers. They also use other natural fibres as wool, tencel or inflò that comes from corn sugar. These companies hardly process these natural fibres. They most likely take them from other enterprises outside of Trentino Region. There are also companies that sell these products (even online) and there's at least one company that is trying to understand if recycling old mattresses can have a positive impact on the market. These are small enterprises with a number of employees up to 10 (at maximum).

There is a strong potential in Trentino in waste coming from grapes or apples that can be used as a recycled feedstock. Grapes are mainly addressed in winemaking industry, with a solid waste, which can be estimated about 30% of the material used (stems, skins, seeds). Average grape production in Trentino region is about 1.200.000 quintals. From 100 kilos of fresh grape, there can be obtained almost 80 kg of must, up to 10 kg of skin, 3 or 4 kg of grape seeds and almost 4 kg of stem. About half of the waste from vineries are sent to the distilleries; some used as biomass, some as fertiliser and a small part is applied in the cosmetic industry. Apple cultivation is the second important agricultural sector in Trentino. The lower quality fruit production is addressed to juice industry, vinegar industry and zootechnical sector.

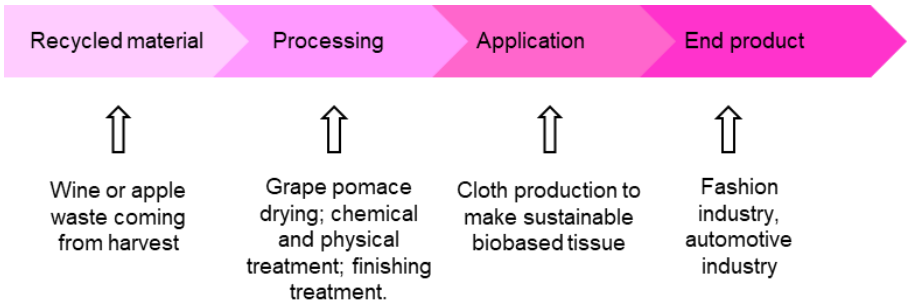

Figure 2. Value chain based on the recycling of waste from apple and grapes production (Trento, Italy)[7]

This is a simplified example of value chain using fruit waste to produce eco-fabrics for fashion or automotive industry. In Trentino there are 155 farms and 15 cooperatives that potentially produce winery waste but there are no companies working on the processing and application of these eco-fabrics. In our region there could be, eventually, some companies working with eco-leather that could also use in their manufacturing eco-fabrics coming from wine or apples.

There is an innovative start-up working with grape fibre and one lab working with apple fibre to make eco-fabrics, but they are not located in Trentino and there are no companies of Trentino involved in these labs.

[7] Self-developed by Hub Innovatione Trentino – Fondazione and Autonomous Province of Trento – Department for Economic Development, Research and Labour. (2019).

Wood sector

In Trentino region, spruce represents 60% of wood. In 2005, spruce forest area was about 137.203 ha. Last available data (September 2019) shows that about 41.583 m^3 of wood has been sold. Most of it (around 39.000 m^3) comes from spruce wood; approximately 220 m^3 comes from larch and 900 m^3 from pine.

The first value chain considers spruce as a feedstock that is processed into wood wool. This natural fibre has breathable features and meets the requirements of sustainable architecture. It is then used to make acoustic insulant panels (e.g. MDF - medium-density fibreboard-panels). In Italy, around 90% of wood waste is turned into particle board or MDF panel board.

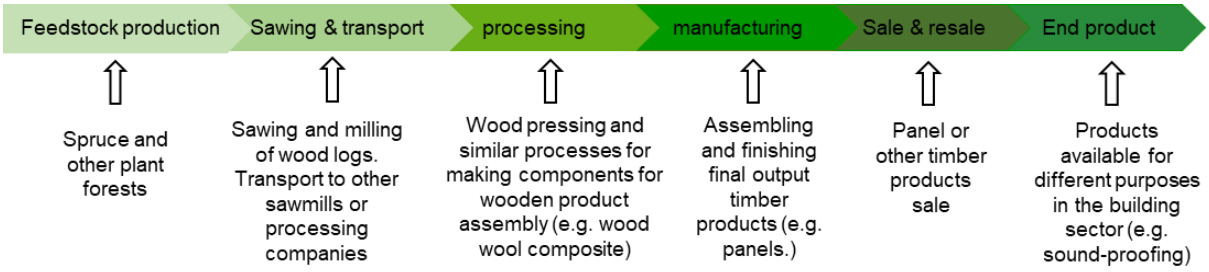

Figure 3. Value chain based on spruce processed into wood wool (Trento, Italy)[8]

It seems that in Trentino there are no enterprises processing wood biomass to make wood wool composite but there are few companies that apply this composite in panels. These companies could either sell panels (e.g. MDF panels) to other enterprises in building industry and to the ones manufacturing doors and windows or they could use them, as end product, because there may be companies working in property renovation. Closest producers of wood wool and fibre boards are located in Veneto (e.g. Celenit) and Sud Tirol (e.g. Leobodner, Nordtex). Woods for the panels come both from Trentino alpine forests and from abroad (e.g. Slovenia).

The second value chain uses as a recycled material wood fibre coming mostly from sawing waste or from forestry conservation works. In Trentino 76% of forest area are public properties, while 24% belongs to privates. Main plants used for wood fibre are spruce, larch and pine. There are around 50 sawmills in Trentino[9] that produce waste with their work which can be ideally used for making wood fibre components.

[8] Self-developed by Hub Innovatione Trentino – Fondazione and Autonomous Province of Trento – Department for Economic Development, Research and Labour. (2019).

[9] We considered enterprises with NACE code 16 narrowing down the research with keywords including sawmill.

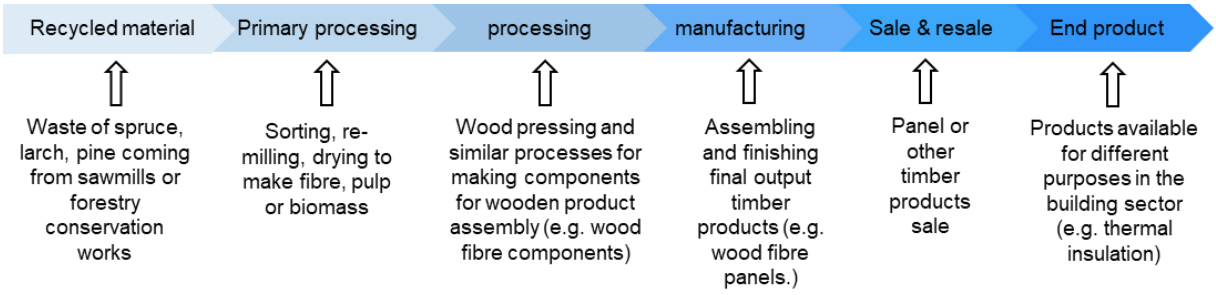

Figure 11. Value chain based on wood fibre from sawing waste or forestry conservation works (Trento, Italy)[10]

Companies process the wood fibre components to make complete panels that are then used as building material. In building industry wood fibre panel are used for thermal insulation, roof insulation, pavements soundproofing.

Digitalization knowledge ecosystem

According to the Digital Economy and Society Index (DESI) of 2019, at the national level, Italy ranks 24 out of 28 EU Member States of the European Commission. To boost the digital transformation of the Italian economy, it is important to raise awareness about the relevance of digitalization in SMEs. The DESI report also highlights that the majority of businesses in Italy (over 55%) have had low investments in digital technologies (i.e. have a very low Digital Intensive Index that measures the availability of 12 different digital technologies at the firm level), often having just a simple website and a few computers.

Concerning the Autonomous Province of Trento, the Regional Innovation Scoreboard 2019 ranks the region as a "moderate+" innovator[11]. The digital transformation potential of the Province is remarkable considering the push for the innovation of the Trentino ecosystem. Trento has also pushed forward the specialisation in a number of manufacturing sectors related to advanced manufacturing and Industry 4.0. The province counts on the strong research capacity of the public and semi-public research institutions (e.g. University of Trento, Bruno Kessler and Edmund Mach Foundations) as well as on the capacity of local SMEs to innovate despite the fact that the small size of companies in Trentino has been presented as a disadvantage for innovation. In 2014, Trento was one of the regions with the highest share of innovative micro-enterprises in Italy (in total 51% vs the Italian average of 45%).

According to a survey of the Chamber of Commerce based on a representative sample of enterprises, 58% of respondents say that their own enterprise is sufficiently technological;

[10] Self-developed by Hub Innovatione Trentino – Fondazione and Autonomous Province of Trento – Department for Economic Development, Research and Labour. (2019).
11 European Commission – Regional Innovation Scoreboard 2019. https://ec.europa.eu/growth/industry/innovation/facts-figures/regional_en

34,5% claim to having increased investments in digital in the last year, while the 57,6% left them unchanged compared to the previous year. Only the 7,9% of the interviewee has diminished the investments. This survey includes enterprises signed in the Enterprises Register of the Autonomous Province of Trento coming from the main sectors closers to the digitalization processes (i.e. commerce, manufacture, hospitality, ICT service, scientific professions).

Trentino ecosystem benefits from the presence of a system of research and innovation with about 4.000 employees in 2016 coming from both the public and private institutions (ISPAT 2019). In 2016 the expenditure in research and development equal to approximately 294,6 mln euro divided into 59,9% coming from the public sector and 37,8% from the private sector (2,4% comes from private no profit institutions). The ecosystem can also rely on other key actors and on numerous events that provide knowledge on digitalization relevant for SMEs.

Regional key actors:

- Autonomous Province of Trento, the regional authority, provides for numerous financial opportunities and program aimed at creating new local economic opportunities and jobs;
- Trentino Sviluppo is the regional agency of the Autonomous Province of Trento that fosters the sustainable growth of the "Trentino system" by developing actions and services aimed at supporting the creation of new entrepreneurial and innovation projects;
- Hub Innovazione Trentino promotes the results of research and innovation in the Trentino system in order to support the development of the local economy through technology transfer activities, acceleration and education to entrepreneurship and strategic projects;
- Fondazione Bruno Kessler is a top research institute in Italy, ranked at the 1st place for scientific excellence within 3 different subject areas (ICT, History and Sociology) and for the economic and social impact;
- Fondazione Edmund Mach promotes cultural and socio-economic growth in the agricultural sector and the development of the forestry and agro-alimentary systems by carrying out research, scientific experiments, education and training activities as well as providing technical assistance and extensions services to companies;
- University of Trento with more than 16.000 students, about 600 professors and researchers it has important departments and facilities in information and industrial technologies;
- Digital Innovation Hub Trentino-Alto Adige[12] offers technology transfer service for enterprises and, following the guidelines of the national plan Industria 4.0, fosters the digitalization process and the introduction of technologies developed by the research institutes of the territory;
- There is a numerous amount of trade association at local level; one of the most important is Confindustria Trento, the Employers' Association of the Province of Trento

[12] https://dih-taa.eu/digital-innovation-hub-trentino/#servizi

representing a system of 800 member companies with about 35.000 employees. It offers customized support on daily business management and administrative operations;

- Camera di Commercio Industria e Artigianato e Agricoltura di Trento (Chamber of Commerce): an autonomy public institution working in the field of market regulation. It offers the Punto Impresa Digitale service to foster and support the adoption of digital technologies in SMEs. It is a service organization located in the Chamber of Commerce dedicated to the promotion of the digitalization culture and its dissemination. The main scope is to create a network of organization for tending to enterprises in the digitalization processes.

Main events:

- Alpine Forum on Smart Industry: dedicated to the opportunities of the digital transformation for SMEs, innovation intermediaries and administrations;
- Trento Smart City Week: focuses on the digital means and services that simplify citizens' life in particular concerning the relationship with the Public Administration;
- National Roadshow Industria 4.0: Internet of Things and Big Data industrial application;
- Seminars organised by the regional agency for development of the Province about topics concerning trends, technologies and services in Industry 4.0 to foster the production process digitalization.

Main drivers for innovation in digitalization:

- Artificial Intelligence;
- Additive and advanced manufacturing;
- Advanced sensors, robotics, Internet of things (IoT), big data analytics are priority areas for Trentino programs fostering digital transformation in industry and agriculture.

Thematic areas:

- Key enabling technology: artificial intelligence will lead to the development of autonomous systems generating strong impact in the fields of automotive, precision farming, manufacturing, avionic and rail industry, security and digital societies;
- Agrifood, natural resources and bioeconomy: it is necessary to accelerate the digitalization and technological innovation in the agriculture sector. Technological operating systems based on artificial intelligence will be the drivers for new organisational models in agri-food production. Collection and processing of big data are two other important drivers for boosting innovation and digitalization in agriculture. Trends: nutrition for disease prevention, sustainable agriculture; circular economy; precision farming; transformation technologies; forest management; biodiversity protection; water management;
- Technologies for decarbonisation: hydrogen and batteries are solutions to environmental issues. Trends: technology for hydrogen production and distribution; hydrogen for transport means; electrical energy storage;
- Biotechnologies and health technologies: in the health sector, the digitalization process fosters the shift towards a predictive and preventive model thanks to the availability of

coded clinical data and omics approach. Trends: microbiology; genomics; predictive models for disease and morbidity; virtual coaching for monitoring and assisting patients.

Political framework

Italy launched the Industry 4.0 strategy in 2016, which the current government takes as a priority. Piano Industria 4.0 (I4.0) is the Italian plan for companies to benefit from a wide range of measures to help them win the challenge set by the digital revolution. The core activities[13] comprise innovative investment, stimulating private investment in the uptake of I4.0 technology, expenditures in R&D, and development of skills. The first group of measures is based on tax incentives. "Hyper and super depreciations" schemes support companies in their tangible investments in their technological and digital transformation processes. The second group of measures ensures easy access to finance. The third group puts an emphasis on the development of skills related to new technologies and innovative processes stemming from the fourth industrial revolution. I4.0 launched the 'Digital Innovation Hubs', which serve as a contact point between companies, investors and research institutions, supporting and facilitating innovative investment plans, and the 'I4.0 Competence Centres', which provide training, live demos, presentation of best practices, technical advisory services for SMEs, launching and accelerating innovative projects and technological development. An additional recent measure has been introduced to help SMEs in their digital transformation - a EUR 40,000 voucher to hire an innovation manager. Every SME can apply (there are some legal requirements they have to fulfil). It is a new chance for enterprises; therefore, there is still no example known of enterprises in Trentino applying for it.

As part of the Industry 4.0 strategy, 22 Digital Innovation Hubs are already active, providing Italian SMEs with services to facilitate their digital transformation and networking in larger digital value chains. Additional instruments, such as the Punti Impresa Digitale (89 so far), promote digitisation, mostly of service sector enterprises. The final component of the Industry 4.0 strategy is the Competence Centres, designed to provide technological advice, to enable SMEs to experiment with new technologies and related ICT training.

In Trentino Region it is also possible to measure the digitalization level of a company through the digital maturity level assessment: a survey available for all Italian Digital Innovation Hubs[14] for assessing the level of digitalization of enterprises and evaluate possible strategies to optimise its internal processes with technologies 4.0. The survey, elaborated from the Politecnico di Milano concerns 130 questions assessing all parts of the enterprise' processes (production, logistics, engineering, marketing, design).

[13] Digital Transformation Monitor: Italy, Industry 4.0. (2017).
[14] https://www.testindustria4-0.com/

Main hurdles to become more innovative

Main issue concerning digitalization in Trentino Region is SMEs knowledge on innovation: they most likely have little comprehension of innovation and digitalization opportunities and benefits and they seem not to be open to it. In addition, according to a survey of the Chamber of Commerce, companies in Trentino Region have to basically rely on their own financial resources for innovation, underling the need to better promote all the measures the government and the key actors are putting in place for fostering digitalization. There are some features blocking the boost of innovation for enterprises: their financial situation and financing conditions; scarce resources availability; their own network (e.g. relationships with other companies, research centres, institutions) and the existence - or not - of an innovative ecosystem.