

The entrepreneurial method as a way to solve the problems of processing wood waste in a circular economy

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Millions of tons of agricultural, agro-industrial waste and forestry waste are generated annually as by-products of the forest industry. Due to ineffective utilization and increase in the amount of waste from agroforestry, the environment, including soil and water, is negatively affected. These wood residues, husks, shells, stumps and dry trees are considered as agroforestry waste due to their low market value; however, they can be used as a source of energy. In the case they are of no use, these materials are destroyed by burning in the open air, which leads not only to a waste of potential energy, but also to problems with emissions into the atmosphere. All this requires alternative management strategies. Reducing the amount of forest and wood waste can be achieved either by reducing the size of wood processing waste or by introducing an entrepreneurial method as a new algorithm for better use of wood waste. The entrepreneurial method fits into the economy of a closed cycle, effectively using waste resources to solve commercial and social problems, namely, for the public through opportunities for employment, sales of waste-based products, and reduction of waste incineration or disposal.

The purpose of the study is to review international studies of the Australian forestry sector, which illustrate how, based on the application of the entrepreneurial method, it is possible to profitably use wood waste as raw materials or resources for the production of new products. To achieve this goal, a review-analytical method was used. When considering the entrepreneurial method, two examples have been analyzed in the work, in which it is shown that the entrepreneurial method depends on the suitability and accessibility of the entrepreneur's environment to ensure a successful and sustainable result, and also illustrated the similarities, differences and alternative approaches to waste management. Re-use of post-production or recycled materials is a modern trend applied in many industries, for example, in the production of chipboards, car tires and plastics. Current work includes a compilation of case studies from the Australian forestry sector on successful efforts to convert wood waste into other products.

Keywords: waste disposal, agricultural waste, forestry waste, agroforestry, circular economy, entrepreneurial method.

УДК 658.477

Предпринимательский метод как способ решения проблем переработки древесных отходов в экономике замкнутого цикла

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Миллионы тонн сельскохозяйственных, агропромышленных отходов и отходов лесного хозяйства ежегодно образуются в качестве побочных продуктов лесной промышленности. Из-за неэффективной утилизации и увеличения количества отходов агролесомелиорации среда обитания, включающая в себя почву, водные объекты, подвергается негативному воздействию. Древесные остатки, шелуха, скорлупа, пни и сухие деревья считаются отходами агролесомелиорации из-за их низкой товарной стоимости; однако они могут быть использованы в качестве источника энергии. В случае неиспользования эти материалы уничтожаются путём сжигания на открытом воздухе, что приводит не только к пустой трате потенциальной энергии, но и к проблемам, связанным с выбросами в атмосферу. Всё это требует альтернативных стратегий управления. Сокращение количества лесных и древесных отходов может быть достигнуто или за счёт уменьшения размера отходов переработки древесины или внедрения предпринимательского метода как нового алгоритма лучшего использования отходов древесины. Предпринимательский метод вписывается в экономику замкнутого цикла, эффективно используя ресурсы отходов для решения коммерческих и социальных

проблем, а именно, для общества за счёт возможностей трудоустройства, продажи продуктов на основе отходов и сокращения сжигания или захоронения отходов.

В статье представлен обзор международных исследований лесного сектора Австралии, которые иллюстрируют, как на основе применения предпринимательского метода можно выгодно использовать древесные отходы в качестве сырья или ресурсов для производства новых продуктов. Для достижения поставленной цели применялся обзорно-аналитический метод. Авторами работы были проанализированы три примера, в которых показано как предпринимательский метод зависит от соответствия и доступности среды предпринимателя для обеспечения успешного и устойчивого результата, а также проиллюстрированы сходства, различия и альтернативные подходы к обращению с отходами. Повторное использование постпроизводственных или переработанных материалов – это современная тенденция, применяемая во многих отраслях промышленности, например, при производстве древесностружечных плит, автомобильных шин и пластика. В рамках проводимой в настоящее время работы обеспечивается обобщение данных о тематических исследованиях лесного сектора Австралии, касающихся успешных мероприятий по перепрофилированию древесных отходов для производства других продуктов.

Ключевые слова: утилизация отходов, сельскохозяйственные отходы, агропромышленные отходы, отходы лесного хозяйства, агролесомелиорация, экономика замкнутого цикла, предпринимательский метод.

The term “Agroforestry” is defined as a land use system in which crops are grown and cultivated along with trees [1]. At the same time, traditional agroforestry lags somewhat behind integrated farming technology, since agricultural crops grow faster than trees, and the resulting waste is defined as agroforestry waste [2–4]. Waste generated can be divided into agricultural waste (peanut shells, rice straw, cane litter, corn leaves, etc.), agro-industrial waste (residue from the processing of rice hulls, peanut shells, coffee husks, etc.) and forestry waste (remaining stumps and foliage after wood extraction) [5]. Due to inefficient disposal, agroforestry waste is currently becoming a serious environmental problem worldwide. Due to their increasing amount, the environment, including soil, water bodies, is negatively affected, which subsequently leads to soil infertility and eutrophication of water [6]. Traditional waste disposal methods include thermal treatment, the creation of municipal solid waste landfills, however, this waste disposal is accompanied by adverse consequences, such as emissions of CO_2 , CO , C_nH_m , SO_x , NO_x , unpleasant odors and groundwater pollution [7–9]. As the amount of waste increases, the cost of disposal eventually increases as well, highlighting the undoubted importance of entrepreneurial methods of converting waste into useful products.

New global policy initiatives promoting the development of the circular economy provide an opportunity to reduce and reuse industrial waste. The timber industry complex is becoming more and more effective in organizing and solving these problems.

In the Russian Federation, in particular, in the Kirov Region, 63% of the territory is covered with forests, and the total timber reserve is more than 1,1 billion m^3 . In terms of timber harvesting, the region occupies a leading position in the

Volga Federal District and is one of the largest producers in the European part of Russia. Nevertheless, the region enterprises process wood waste inefficiently, entrepreneurship being poorly developed within the framework of the circular economy. In this paper, we analyze case studies from the Australian timber industry to illustrate how Australian businesses use leftover woodworking to scale up entrepreneurial initiative. We have found that the potential social and economic benefits extend far beyond the mainland where this entrepreneurial activity takes place. Innovation often spurs other innovations, which leads to a virtuous cycle in the emerging circular economy of regional Australia. Thus, for the efficient use of wood waste, it is necessary, in our opinion, that the timber industry of the Kirov Region follow the example of the Australian agriculture which uses entrepreneurial initiative in solving the problems of further waste processing.

The purpose of the study is to review international studies of the Australian forestry sector that illustrate how wood waste is actively and profitably used to manufacture new products. An entrepreneurial approach based on the effective assessment of commercial and social problems fits well into the circular economy of the forestry sector in Australia, rationally using waste resources to create additional opportunities for society through employment, the sale of products based on recycled waste and the reduction of incineration or landfilling of this waste.

The paper examines in detail the use of the entrepreneurial method of the above-mentioned country to explore the possibilities of enterprises, which range from sustainable sources of resources to consumption and investments focused on environmental conservation and social development. This method allows you to keep the value of things, materials and resources in the economy for as long as possible.

Objects and methods of research

To achieve this goal, a survey-analytical method has been used. Keywords in the bibliographic databases of scientific citation Web of Science Core Collection (Clarivate Analytics) have been used to select information for the study. The search for information sources took place in the search engines Yandex and Google. The review of the entrepreneurial method and approaches to its use includes sources published from 2001 to the present. The search for information has been carried out in international, interdisciplinary, scientific, peer-reviewed open access journals on environmental and economic issues using the keywords: waste management, agricultural waste, agro-industrial waste, forestry waste, agroforestry, circular economy, entrepreneurial method.

Research results

While wood waste recycling is beneficial to forestry firms, on the bases of the sources analyzed, we believe that the social and economic benefits go well beyond the region in which this activity takes place.

The authors of [10] have developed a technology and innovation roadmap that is used to support strategic and long-term planning in identifying opportunities to reduce the impact of forest waste on the environment and public health in Australia.

The search for the relationship between the entrepreneur and the environment lies in the adoption of an entrepreneurial perspective, in which environmental pollution, which is a global problem, can be seen as an opportunity for further development [11].

Reuse of post-manufactured or recycled materials is a modern trend applied in many industries, for example, in the production of particle boards [12], car tires [13] and plastics [14]. The roadmap [10] takes a detailed look at the challenges facing the Australian paper industry and sets out the necessary conditions to reduce, recycle and repurpose paper waste to create new products and new markets in Australia's emerging circular economy. The goals of the circular economy require entrepreneurship to develop and exploit new market opportunities [11].

External factors arising from forest management, including the impact of climate change, waste disposal, the landfill problems, water and food safety, are forcing forestry enterprises to reconsider their attitude to the natural and so-

cial environment. 3M Company (is an American multinational conglomerate operating in the fields of industry, worker safety, U.S. health care, and consumer goods) has recognized that commercial waste streams consist mainly of unused manufacturing resources, and pollution levels from manufacturing indicate inefficient processes [14]. As a legal remedy, 3M Company has developed a set of effective methods for waste disposal "Pollution, Prevention, Pay" [15]. Unfortunately, not all waste can be eliminated, which further leads to the search for new technologies and business models for the profitable repurposing of commercial waste, which currently form a circular economy [16], i. e. a production and consumption model that includes sharing, renting, reusing, repairing, upgrading and recycling existing materials and products for as long as possible.

The authors of [17] note that the circular economy is a process that includes the reduction, repurposing, recovery and recycling of waste. Earlier studies in the field of circular economy gave focused on the forest industry and the production of wood products [18, 19], for example, on the application of new technologies, such as the process of processing forest and wood waste into a bio-product, which is then processed into fuel and chemicals. However, at present, enterprises participating in the circular economy must, first of all, think about how they will process a huge amount of waste into commercially viable products for already existing or new markets [20, 21].

Reducing the amount of forest and wood waste can be achieved by reducing the size of wood considered as waste in production processes, reducing the size of wood processing waste [22] or introducing new algorithms for better use of wood cutting lines [23].

The entrepreneurial approach [24–26] as a tool for the circular economy is a method based on the effective assessment of the implementation of commercial and social problems, including the problems of waste and climate change as potential commercial opportunities. The implementation of entrepreneurial opportunities consists of the following processes [26, 27]: 1) recognizing one's and organization's potential strength and resources; 2) use of unforeseen circumstances and accidents as a source of opportunities; 3) pooling partners' resources to achieve the goal. The entrepreneurial approach fits into a circular economy by leveraging waste resources to solve commercial and social problems, namely for society through employment

opportunities, selling waste-based products, and reducing waste incineration or landfilling.

As discussed above, the review of international studies includes the Australian forest industry as an illustrative example of how the forest industry uses the residues from wood waste collection to develop a sustainable entrepreneurial initiative [28]. Achieving this goal requires the Australian forestry sector to follow the example of Australian agriculture and to fully embrace entrepreneurship as a necessary capability for its survival (e. g. [29]).

The entrepreneurial method creates economic opportunities for sustainable management of environmental, social and economic development [30]. In their research, the authors of [31] show how forest entrepreneurship initiatives arise to solve the problems faced by forestry enterprises, namely, the forest industry acts in an entrepreneurial way, creating and using resources for the development of sustainable production. In order to have the right combination of skills to successfully manage a forest industry enterprise, it is necessary to develop entrepreneurial competencies in the education and training programs for future forest managers [32–34], increase their entrepreneurial potential to recognize, evaluate and, ultimately, use the attractive opportunities created by Australia's emerging closed economy.

Entrepreneurship in the forestry of the region under consideration is primarily focused on the conservation of the environment, as well as on the search for prospective opportunities to create future products and services for profit, where profit is broadly understood as economic and non-economic benefits for the economy and society as a whole [35]. This may include setting waste prices [36, 37] to better manage waste and comply with pricing requirements [38] to incentivize recycling organizations to behave appropriately or to find alternative ways to reduce waste. As the value of waste increases, more firms are innovating to capture the beneficial opportunities of waste management. Recognizing strategic entrepreneurship as a way to seize opportunities and solve problems can help to further develop the forest industry and make it more sustainable. Strategic entrepreneurship supports initiatives that bring together or integrate behaviors and resources that drive innovation [39].

In reviewing the entrepreneurial approach, the paper has analyzed three case studies that present how the entrepreneurial approach depends on the suitability and acces-

sibility of the entrepreneurial environment to ensure a successful and sustainable outcome, as well as illustrating similarities, differences and alternative approaches to waste management. Let's consider the factors of realizing the opportunities of each analyzed enterprise of the forest industry in Australia: 1) resources and use of forest waste biomass; 2) the weight of wood residues of logging enterprises.

Resources and use of forest waste biomass

Converting forest waste biomass into sustainable bioenergy is one of the innovative approaches to help minimize climate change and provide an additional source of energy. Australia has developed a 20% impact targets for renewable energy in gross energy consumption by 2030. Using forest waste biomass for sustainable bioenergy production is one way to achieve these renewable energy targets [40, 41]. Forest biomass can be obtained from conventional wood products, standing timber, logging waste, as well as materials and waste from industrial wood processing [42]. Due to the low energy density and long transport distance from remote forest resources, forest biomass is usually used locally. There are currently several programs in the country to combine wood waste with existing coal resources in New South Wales (NSW) and several pelleting plants, such as the one in Albany [43].

It should be noted that the main sources of forest biomass in Australia are wood residues from logging enterprises, special plantations for energy production, and wood residues from sawmills [44]. According to Australian Biomass for Bioenergy Assessment (ABBA) Project, the estimated weight of wood residues from logging enterprises is about 2.1 million tons of dry biomass per year [45–47].

Weight of wood residues of logging enterprises

The weight of wood residues depends on various parameters such as the harvesting system used, equipment, product type, forestry regime, appearance, site, age and quality of the stand. Scientists have conducted research on various aspects of the mass of wood residues: the quantity and quality of produced wood chips [48], species (including hardwoods and conifers) [49, 50], moisture content [51, 52], type of machine and its working units [53–55], the drive

mechanism of shredders, including machines of small and large power [56, 57], the wear of knife blades [58, 59] and the size of the sieves used in grinding operations [60–63]. Proper collection of wood residues can reduce fire risk by removing fuel from the forest floor, minimizing the risk of beetle attack, and preparing the site for tree planting [64, 65]. From an ecological point of view, properly harvested tree residues can improve soil structure [66], help resist soil compaction, provide a buffer against erosion, and improve water filtration [67].

A 31-year-old radiata pine (*Pinus radiata*) plantation near Mount Gambier was chosen as the first target for international study. It has been clear cut with the help of combine harvesters and forwarders. Hancock Victorian Plantations (HVP) sawmills used innovative technologies such as the Bruks mobile shredder to collect wood residue and chips while leaving enough wood residue on site to maintain soil fertility. The produced wood chips were then transported to the mill at Mount Gambier as raw material [68, 69]. This biomass supply chain created jobs at every stage of production, since a large amount of equipment was used (for example, the Bruks mobile crusher). The main factors that influenced Hancock Victorian Plantations (HVP) to initiate this project were the following: a) reducing the weight of wood waste to improve the efficiency of the site preparation and planting; b) creating additional income from wood resources; c) testing new biomass production technology in active partnership with forestry companies; d) reducing the risk of fire. The second international study selected was a plantation of radiata pine (Tumuta, New South Wales). The age of this plantation is 34 years [70]. The trees were cut down and processed by a mechanical harvester. The wood chips obtained from waste disposal were of high quality and were sent to a pulp and paper mill in New South Wales [71]. Assuming that more than 300,000 tons of wood waste will be collected in the region, this innovative biomass recovery has created an opportunity to create about 20 additional jobs. The main factors that have influenced forestry enterprise Forest Corp NSW to test forest biomass harvesting are the following: a) reducing the weight of wood waste to improve the efficiency of the site preparation and planting; b) creating additional income at the expense of its resources; c) reducing the risk of fires associated with wood resources; d) innovation in integrating biomass recovery with traditional wood waste collection operations.

The third international study is devoted to the integrated collection of biomass on a plantation of radiata pine, located in the southwest of Western Australia. This plantation is 32 years old. The area was cleared with a combine and forwarder where the trees were felled and processed into lumber and pulpwood using innovative technology. A comprehensive biomass case study provided an opportunity to create 15 additional jobs. The Washington State Forest Products Commission (FPC) in Western Australia tested wood residues and noted the following factors: a) great success in the use of integrated harvesting of woody biomass; b) reduction of wood waste to improve the efficiency of site preparation and planting; c) creating additional income at the expense of its resources; d) reducing the risk of fires associated with wood resources.

Thus, the presented examples illustrate potential ways for further development of forestry. It should be noted that various combinations of entrepreneurial activity and the environment lead to successful approaches and strategies for the problems of wood waste processing [70]. It is very important to find the right balance between the business environment and its capabilities to solve these problems.

Conclusion

A review of published sources on the problems of processing wood waste indicates that there is significant experience in forming a scientific base that allows to develop a general methodology and a set of specific measures aimed at protecting the environment. The experience of Australian forestry illustrates potential ways for further development of forestry, in particular for the forest sector of the Kirov Region, namely, the use of business in the field of wood waste processing as a necessary side of its development.

It should be noted that various combinations of business activities and the environment lead to successful approaches and strategies for wood waste problems [70]. In this regard, it becomes possible to create positive cycles in the economy and the ecosystem, which, thanks to the protection of the environment, are necessary for the development of a sustainable economic system.

The examples analyzed in this article show that there are various organizational goals of sustainable development in forestry, which include profit and social sphere, which leads to effective joint efforts to ensure economic (costs and profit), social (employment, safety and working conditions) and environmental (impact on waste

and long-term effects) balance. Thus, a clearly articulated overall goal helps to pool resources through innovative entrepreneurial strategies to address the challenges of wood waste recycling.

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