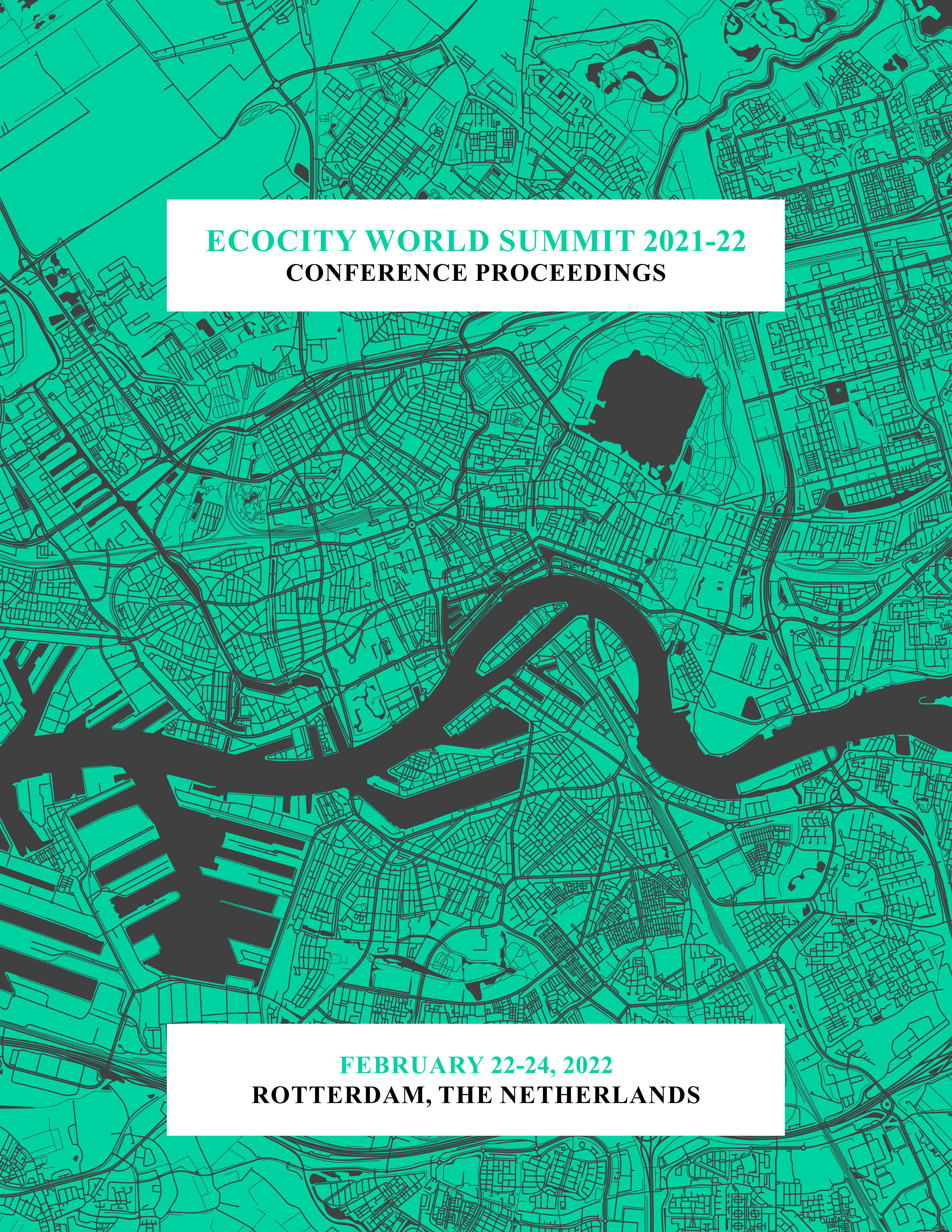

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www.ecocitybuilders.org
info@ecocitybuilders.org
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PROMOTING BIO-BASED BUILDING MATERIALS AS A MEANS OF BRIDGING THE URBAN-RURAL DIVIDE IN SERBIA

Ilija Bošković
University of Belgrade Faculty of Architecture
ilija.boskovic@bath.edu

Ana Radivojević
University of Belgrade Faculty of Architecture
ana@arh.bg.ac.rs

ABSTRACT

Due to the difficult economic situation within Serbia, rural areas find themselves on the margins of investment and development, creating a deep rural-urban divide. Much of Serbia can be characterized as rural with a large segment of the population living in rural settlements defined by socio-economic stagnation or degradation. Revitalizing rural regions is thus important for the socio-economic wellbeing of the entire country and mitigating the rural-urban divide can be key to the sustainable development of urban areas. Much of the built environment in Serbia has a low level of energy efficiency and though public perception has improved, the focus is on improving operational energy, while the embodied environmental impact of building materials is rarely considered. This paper details and analyses the main problems facing rural areas in Serbia. As agriculture is still the primary economic activity in rural areas, it suggests that the development and application of bio-based building materials created from the by-products of agriculture, can be an important element of further strategies for sustainable development in Serbia. In particular industrial hemp, which was once an important and abundant crop in Serbia, is currently experiencing a significant resurgence. This paper demonstrates that hemp-lime concrete may be a particularly suitable building material for encouraging new economic activity in rural areas and promoting sustainable design in both rural and urban areas.

KEYWORDS

Urban-Rural divide, Rural Development, Bio-based building materials, Industrial hemp, Hemp-lime concrete

INTRODUCTION

Representations of the rural have differed throughout history and are dependent on a wide range of influences. Traditionally the rural may be associated with nature, agriculture and community life, but no universal definition exists. The rural is thus a complex, contested and ambiguous space which has been defined through various conceptual approaches and definitions over the years. Though interconnected, the rural has also generally been seen as separate from the urban and has often been defined negatively as non-urban or as subservient to the urban. In Serbia, since 1981, settlements have been classed as either "urban" or "other" based on the administrative decisions of local government offices. Of 6158 settlements, 193 are classed as urban, while the other 5956 can be considered rural [1]. Though they aren't clearly or universally defined, rural spaces and rurality still hold a prominent place in the social consciousness of Serbia. Unfortunately the unfavourable economic situation in the country has particularly affected rural areas and has led to their socio-economic degradation. Though urban areas have also suffered, in general they are able to provide a higher quality of life to their residents. These spatial and socio-economic divisions have engendered a deep rural-urban divide, which has also been fostered on a political level, as rural areas are marginalized and left without the institutional and economic support required for their continued development and wellbeing. Rural areas are home to 39.8% [2] of the population, thus it is clear that improving their socio-economic standing is also key for the overall development of country.

The socio-economic deprivation inevitably also has a negative effect on the natural and built environment. The national strategy for rural development is primarily centred on agriculture, as defined in "The Strategy for agricultural and rural development of the Republic of Serbia 2014-2024" [1]. The five main strategic goals aim to increase producer income, introduce technological advancements into agriculture, improve environmental protection, implement sustainable resource management, reduce poverty, improve the quality of life in rural areas and improve the institutional framework for rural development. The production of bio-based building materials from the by-products or co-products of agricultural production can be seen as a part of these wider strategies and can have wide reaching benefits for both rural and urban areas. Bio-based building materials make use of renewable and biodegradable components that sequester carbon dioxide from the atmosphere through photosynthesis. Though socio-economic differences between rural and urban areas may be pervasive, the differences in single family housing typology are not as pronounced. Studies into the typology of family housing in Serbia [3,4], have shown that most of the existing single family housing stock was built in the second half of the 20th century, when environmental sustainability and energy efficiency were low design priorities. As Jovanović Popović et al. [3] indicate, since the 1970s the same housing typologies can be found in all regions of Serbia, thus the same comfort and energy efficiency issues permeate both rural and urban areas. The main aim of this study is to analyse the opportunities and implications of introducing bio-based building materials into construction practices in Serbia as a means of promoting rural development. As industrial hemp is currently experiencing a resurgence in Serbia, the paper will primarily focus on lime-hemp concrete.

THE RURAL – URBAN DIVIDE IN SERBIA

The initial draft document for the "Spatial Plan of the Republic of Serbia 2021 to 2035" [5], indicates that despite the existence of previous spatial plans and strategies, polarization between large urban centres and smaller urban centres and rural areas, still persists. Key statistics demonstrating the socio-economic disparities between rural and urban areas are shown in Table I.

Table I: Key socio-economic statistics of rural and urban areas in Serbia

	Urban	**Other (Rural)**
Population 2011[2]	59.1%	40.9%
Population 2020 [2]	60.2%	39.8%
Average age [2]	42.4	45.1
Monthly monetary household income, 2019 [6]	68765 RSD	57885RSD
Absolute poverty rate, 2016 [7]	5.1%	10.5%
Risk of poverty, 2020 [8]	14.6 - 18.1% depending on density	30.7%

Due to a low natality rate, an aging population and a high rate of emigration, Serbia is faced with a declining population. It is estimated that the population has fallen by around 4.7% between 2011 and 2020, with depopulation predominantly affecting rural areas. During this period only the region of Belgrade, consisting of the capital city and its surrounding areas, achieved population growth. Based on the results of the last national census in 2011, rural areas had a worse overall level of education with a higher percentage of residents without a formal education and a lower percentage with a higher education [9]. Thus though the whole country is facing a demographic crisis, rural areas in particular, are being affected by a loss of human capital. The region of Belgrade is responsible for the production of 41.7% of the total national GDP with an average GDP that is 70.8% higher than the national average [10]. This is indicative of the effects of centralisation and the level of financial disparity between primarily urban and rural regions. On average households in urban areas have a 15.8% higher monetary income, than rural households [6]. The absolute poverty rate and risk of poverty is also much higher in rural areas, than in urban areas. Centralization and uneven development have left many rural areas devoid of services, infrastructure and economic opportunities, which has in turn led to their socio-economic degradation.

Agriculture is still the primary economic activity in rural areas and is seen as the primary sector through which any rural development can be enacted. Table II and III present key statistics describing the structure of farm holdings in Serbia.

Table II Key statistics for farm holdings in Serbia 2012 & 2018 [11]

Year/ Total farm holdings	**Total associated workers**	**Family holdings**			**Legal entity holdings**			**Total averages**	
		Total (%)	**Average Size (ha)**	**Average standard output (€)**	**Total (%)**	**Average size (ha)**	**Average standard output (€)**	**Size (ha)**	**Standard output (€)**
2012/ **631552**	1416349	99.5	4.48	4990	0.5	204.12	204755	5.44	5939
2018/ **564541**	1318593	99.7	5.2	7470	0.3	364.20	398518	6.16	8610

Table III The composition of farm holdings in Serbia according to size [12,13]

Year/ Total farm holdings	**0-2ha**		**2.01-5ha**		**5.01-10ha**		**10.01-50ha**		**50.01-100ha**		**>100ha**	
	Share (%)	**Land use (%)**	**Share (%)**	**Land use (%)**	**Share (%)**	**Land use (%)**	**Share (%)**	**Land use (%)**	**Share (%)**	**Land use (%)**	**Share (%)**	**Land use (%)**
2012/ **631552**	48.12	7.7	29.3	17.32	14.29	18.03	7.29	24.13	0.69	9.03	0.28	23.8
2018/ **564541**	39.15	6.29	32.8	16.95	17.05	19.13	10.27	30.08	0.68	7.37	0.25	20.16

The 2018 agricultural poll reported a 10.6% reduction of farm holdings, compared to the last agricultural census in 2012 [11]. Though the total number of people associated with any degree of agricultural work has fallen, the average number of workers per holding has risen. As around 99.7% of holdings are considered "family holdings", few people are employed as full time workers with most of the workforce being made up of farm owners, their families and day labourers. However only 10.7% of the total income of the average rural household came from agriculture, which is down from 13.3% in 2012 [6]. Income from full time employment and pensions accounts for a higher percentage of household income, showing that many rural residents are employed in other sectors and use agriculture as a means of gaining an additional income. This is reflected by the small size and low value of many family holdings. Though farm holdings appear to have gotten slightly larger, with a relative increase in medium to large holdings (5-50ha), overall they are still relatively small. Farm holdings under 5 hectares, still make up the majority of farm holdings even though they use less than a quarter of the cultivated agricultural land. The small size of the farm holdings is compounded by their low value. The average standard output in 2018 was €8610, which is very low compared to an average standard output of €34785 by EU farm holdings in 2016 [13]. There is a vast difference in size and output between the average family and legal entity holdings. With the largely extensive nature of production and so many farm holdings of low standard output, agriculture in Serbia is particularly sensitive to the effects of climate change [1]. While the primary national development strategies [1,5], highlight the importance of improving the sustainability and environmental effects of current farming practices, little mention is made of the potential benefits of using agricultural crops for creating more environmentally friendly products. Though growing crops for biofuels is mentioned, the use of agricultural by-products and co-products for making bio based-building materials, is not discussed.

INDUSTRIAL HEMP CULTIVATION

Interest for industrial hemp has been growing worldwide as a result of the need for more sustainable raw materials and the increased demand for CBD (cannabidoil) in the pharmaceutical industry. Industrial hemp is a versatile crop, as every part of the plant has commercial uses. The plant can grow up to 5 metres tall and has a thin stalk which consists of a hollow woody core on the inside and the bark, which contains fibre bundles, on the outside. The fibres are used for making industrial textiles, paper, thermal insulation and technical fibre in various biocomposites. The seeds and the oil extracted from the seeds can be used for producing various food products, dietary supplements, cosmetics and other various industrial products. The flowers are primarily sought by the pharmaceutical industry for CBD, which is used in various novel medical products. Finally the woody core or shivs are the co-product of fibre extraction and are used as animal bedding, mulch and a primary raw material for hemp-lime concrete. Industrial hemp is quite resilient, as it doesn't require the use of pesticides and herbicides. It is also adapted to a wide range of soil and climate conditions and can be used in rotation with other crops [14]. One can agree with Stanwix and Sparrow [15], that though industrial hemp shouldn't be considered a "miracle crop" which can resolve all the problems of the modern world, it possess many advantages and it could be an important material for creating more sustainable products in the future.

The soil and climate conditions in Serbia are suited for industrial hemp cultivation. This is reflected by the rich historical context of industrial hemp production. During the early and mid 20th Century, as part of Yugoslavia, Serbia was one of the largest industrial hemp producers in Europe. From 1948 to 1952, an average of 70000 hectares was sown with around 70% of the crop cultivated in Serbia [16]. A steep decline in production began in the 1960s, which culminated in the closure of all processing plants and a cultivated area of only 60 hectares in 2015. Since then, interest in the crop has grown and production has risen steadily. It is estimated that around 1500 hectares were cultivated in 2020 and an increase to over 10000 hectares is expected in the coming years [17]. Potential limiting factors to further expansion, are the stigma surrounding the appearance of the crop and the need for licences and government control. The cultivation of industrial hemp requires a licence from the Ministry of Agriculture [18]. Though the terms could be more liberal, the requirements of the legislation are primarily of an administrative nature and shouldn't present an insurmountable barrier to anyone interested in growing industrial hemp. Therefore the main limiting factor will be the profitability of industrial hemp production and processing. With increased cultivation worldwide, competitiveness is key. Potentially lower production costs are an advantage, but the lack of cultivar diversity could be an issue. Currently, only six cultivars can be grown legally [19], which could potentially inhibit the future competitiveness of Serbian hemp products on the worldwide market. However, with the expected growth of production and the development of new processing plants, there is a great potential for manufacturing and using building materials from industrial hemp.

THE PROPERTIES OF HEMP-LIME CONCRETE

Though hemp fibres can also be combined with a polymer based binder to make insulation batts and boards, this study will primarily focus on hemp-lime concrete, as it is the most prominent and versatile building material originating from the hemp plant. Hemp-lime concrete or "hempcrete" is a composite building material made by mixing hemp shiv with a lime based binder and water. It was created in France in the 1980s as a replacement for wattle and daub in historic buildings and can be used in new construction, energy renovation and historical restauration [15]. Though it can also be used for roof and floor insulation, it is primarily used for wall construction. It isn't a load bearing material and has to be cast around a structural frame or applied to the surface of an existing solid wall. It is most often cast in situ around a timber structural frame, but can also be prefabricated into blocks or panels. Depending on density, hemp-lime concrete walls have a relatively low dry thermal conductivity of around 0.06 to 0.12W/mK [20]. This is notably higher than the thermal conductivity of typical thermal insulation materials such as stone wool and EPS, which usually varies from 0.03 to 0.04W/mK. However studies have shown, that due to its porous structure and hygroscopic nature, hemp-lime concrete possesses an excellent moisture buffer capacity and good thermal inertia [20, 21, 22, 23, 24]. Under dynamic conditions, hemp lime concrete is able to buffer the effects of outdoor humidity and temperature variations, thus maintaining a stable and comfortable indoor environment and reducing the need for active climate control.

Hemp-lime concrete makes use of a renewable and biodegradable raw material, which had limited uses as mulch or animal bedding. During its short growth cycle hemp shiv sequesters carbon dioxide from the atmosphere, reducing the environmental impacts of the material. Existing LCA studies show that various functional units representing a $1m^2$ wall of hemp-lime concrete cast around timber studs, sequester more greenhouse gases than they release and have a negative global warming potential (from -36.08kg $CO_{2eq.}$[25] to -1.6kg CO_{2eq} [26]). Assuming a carbon content of 46% in hemp shiv [27] and a moisture content of 11% [28], 1kg of hemp shiv can sequester 1.5kg of carbon dioxide. The implications of using hemp-lime concrete in Serbia hasn't been sufficiently studied, as the construction of only one hemp-lime concrete building has been publicized, so far.

THE SINGLE FAMILY HOUSING STOCK AND CONSTRUCTION PRACTICES IN SERBIA

Single family housing is the dominant residential typology in rural areas and in Serbia as a whole (92.13% of the total buildings and 69.22% of the dwelling units [4]). Though there is a need to raise awareness about the benefits and need for energy efficiency, Jovanović Popović et al. [3] indicated that people were generally aware of the benefits of energy savings through improvements to the thermal envelope of their home. In the years since their study in 2012, energy renovation has become more prevalent. Though the difficult socio-economic situation in the country has made energy renovation more difficult and slowed down the ingress of environmental design principles. The energy efficiency of buildings is regulated by the "Regulations for the energy efficiency of buildings" [29], which primarily focuses on the operational energy of buildings. The embodied energy of building materials isn't taken into account as a means of improving the environmental sustainability of buildings. Buildings are certified with energy passports, which classify them into energy grades according to their final heating energy consumption [30]. Thus the construction context in Serbia is characterised by a large section of housing stock that doesn't satisfy current energy efficiency standards and current new build and renovation practices that don't take into account resource consumption and the embodied energy of building materials.

The oldest buildings in rural areas are examples of vernacular architecture built in the 19th century using wattle and daub or rammed earth. Construction using traditional techniques and materials ceased in the first half of the 20th century (Fig. 1).

Fig. 1. The house of Živojin Mišić in Struganik, an example of 19th century vernacular architecture in Serbia (own photo)

In 2013, family housing built before 1919 made up around 5% of the housing stock [4]. Unfortunately many of these buildings are in a bad state of disrepair and their restoration must primarily be approached as a means of preserving architectural heritage. As a vapour permeable material created as a replacement for wattle and daub, hemp lime concrete is ideal for both the physical reconstruction and energy renovation of Serbian vernacular architecture. Following the introduction of masonry in the early 20th century, rural areas started to look to urban housing for inspiration. Thus over the course of the 20th century differences in the construction, organization and appearance of urban and rural single family housing, disappeared (Fig. 2).

Fig. 2. Examples of typical 20th century single family housing in Serbia from 1971-2012 [4]

Much of the existing housing stock utilizes masonry construction and doesn't meet the requirements of the energy efficiency regulations. The primary aim of energy renovation practices is to meet or surpass the required thermal transmittance values for the thermal envelope, set by the regulations. In practice, this is primarily achieved using ETICS façade systems, which utilize stone wool or EPS insulation and are finished with thin layer silicon, silicate or acrylic renders. New buildings are also primarily constructed using hollow clay blocks or thermal clay blocks with an ETICS façade system. Thus both energy renovation and new construction primarily only focus on reducing operational energy through the use of inorganic and nonrenewable building materials. The choice of insulation materials is primarily driven by cost, which has also limited the variety of insulation products available on the Serbian market. As operational energy accounts for most of the energy used during a building's lifecycle, bio-based materials with a lower embodied energy, still need to match or exceed the operational performance of conventional building materials to be considered completely effective. Therefore, hemp-lime concrete constructions can only be considered superior to current practices in Serbia, if they have lower embodied environmental impacts at the same operational energy usage.

DISCUSSION

It can be argued that there is both an opportunity and need for the introduction of bio-based building in Serbia. Hemp-lime concrete in particular appears to be a material that can have a positive effect on agriculture and the built environment as whole. From the aspect of agricultural development, industrial hemp is an in demand crop that can be used to create a wide variety of products and presents many opportunities for the diversification of economic activities in rural areas. It can also contribute to more positive farming practices, as it doesn't require phytosanitary protection. Due to its vigorous growth industrial hemp also leaves the land clear of weeds and returns significant organic matter to the soil post harvesting [14]. A disadvantage is that it still requires the use of nitrogen, phosphorous and potassium fertilisers, which contribute to the emissions of ammonia, nitrates, nitrous oxide and phosphates. Though according to van der Werf [31] industrial hemp in general requires less nitrogenous fertiliser than sunflower, oilseed rape, wheat, corn, potato and sugar beet. The average yield of the local Helena cultivar is 10t/ha, which according to Bevan and Woolley [14] is enough to build one lime-hemp concrete house. Though the idea of occupying agricultural land for creating building materials may seem problematic, hemp shiv is simply a co-product of hemp fibre extraction and not the sole or primary product of industrial hemp cultivation. It is also important to note that in 2018 around 5.6% or 289953 hectares of the agricultural land held by farm holdings in Serbia wasn't cultivated [12], thus increased industrial hemp production need not jeopardize the cultivation of other crops.

It is important to note that though the production of industrial hemp is primarily tied to the agricultural sector, the development and production of hemp-lime concrete in Serbia is also dependent on the interest and cooperation of multiple industries. Processing plants would be required for hemp shiv extraction and binder production. An important question to consider, is whether a binder can be developed in Serbia using mostly locally produced raw materials or whether the established practice would be to import existing proprietary binders. Introducing hemp-lime concrete to the Serbian market, either through importing or manufacturing, is inherently a private endeavour. However, as Nozahic and Amiziane state [32] in order create a market for bio-based building materials, private actors may require the provision of help through financial incentives. This help may come from the state or local government in the form of tax incentives or subsidies to encourage people to use bio-based building materials.

Though current building regulations promote energy efficiency, they don't promote sustainability in a wider sense, by encouraging the reduction of embodied energy and effective resource management. Bio-based building materials can be useful in mitigating climate change and resource depletion. Therefore promoting materials such as hemp-lime concrete through changes to regulation and subsidies could become a part of national sustainability strategies. The low human, social and economic capital in rural areas makes starting endogenous development projects difficult and greatly limits their chances of success. Thus, as Bogdanov [33] and Mitrovic [34] argue, exogenous state interventions are almost certainly still required to raise the low level of territorial capital in rural areas and encourage development.

One further means of promoting bio-based materials in Serbia, might be to promote the use of hemp-lime concrete through building heritage restoration projects. Many traditional rural buildings require restoration and utilize wattle and daub construction. Architectural heritage is an important part of every nation's history and cultural identity and their restoration should be an important aspect of any rural development strategies. In addition, both the national rural development strategy [1] and spatial plan [5] highlight the potential role of cultural heritage in promoting rural tourism and the diversification of economic activities in rural areas. However hemp-lime concrete shouldn't be limited to rural areas and should be promoted as a material, which can be used in new construction and restoration throughout the country, opening up a knowledge transfer between urban and rural areas. Additionally, as thermal transmittance [20, 22] is not an adequate measure of the thermal performance of hemp-lime concrete, its operational performance cannot be adequately evaluated according to current building regulations in Serbia. Thus a willingness to adjust building regulations may also be a key to promoting the use of the material. One issue which may limit use of the material in practice is the lack of trained experts with experience in using hemp-lime concrete. Though this can also be an opportunity for the formation of new construction specialists and the transfer of new skills and jobs to rural areas. As hemp-lime concrete is an innovative and relatively new building material, reservations regarding the effectiveness of bio-based building materials may be a primary barrier to establishing a market. Ultimately it may be economic considerations and its cost effectiveness compared to conventional building materials that dictates the applicability of hemp-lime concrete in Serbia.

CONCLUSION

Rural areas in Serbia are characterised by socio-economic degradation and a largely energy inefficient housing stock. Centralised decision making and a lack of practical interest in rural development have created a measurable rural-urban divide. Though they shouldn't be regarded as the sole force for driving rural development, the promotion and implementation of bio-based building materials could be a means of furthering the concept of environmental sustainability in rural areas. Hemp-lime concrete appears to be a particularly suitable material, due to its versatility, carbon dioxide sequestration, positive hygrothermal behaviour and the growing interest in industrial hemp cultivation in Serbia. Industrial hemp is a multifaceted crop which can have a role is diversifying economic activities in rural areas, while hemp-lime concrete can have an important role in the restoration of architectural heritage and the reduction of embodied energy in the built environment. The impact and success of hemp-lime concrete in Serbia will primarily depend on its ability to match or exceed the thermal performance of conventional materials at a similar or lower price point. Studies regarding the applicability of hemp-lime concrete in the context of Serbia are crucial for its further promotion. It would be significant to analyse the operational performance of the material in the local climate through simulations or experiments and to analyse the environmental implications of making and using the material through a lifecycle assessment, which could also compare it to existing practices.

REFERENCES

[1] Ministry of agriculture, forestry and water management of the Republic of Serbia. (2014). *Strategija poljoprivrede i ruralnog razvoja Republike Srbije za period 2014-2024. godine* [*The strategy of agricultural and rural development of the Republic of Serbia 2014-2024*]. http://uap.gov.rs/wp-content/uploads/2016/05/STRATEGIJA-2014-2020-.pdf

[2] Statistical office of the Republic of Serbia. (2021). *Estimates of population, 2020* (Statistical Release 181-year. LXXI). https://publikacije.stat.gov.rs/G2021/PdfE/G20211181.pdf

[3] Jovanović Popović, M., Ignjatović, D., Radivojević, A., Rajčić, A., Đukanović, Lj., Ćuković Ignjatović, N. & Nedić, M. (2012). *Atlas of family housing in Serbia*. University of Belgrade Faculty of Architecture.

[4] Jovanović Popović, M., Ignjatović, D., Radivojević, A., Rajčić, A., Đukanović, Lj., Ćuković Ignjatović, N. & Nedić, M. (2013). *National typology of residential buildings in Serbia*. University of Belgrade Faculty of Architecture.

[5] Institute of Architecture and Urban & Spatial Planning of Serbia. (2021). *Prostorni plan Republike Srbije 2021. do 2035. godine* [*Spatial Plan of the Republic of Serbia 2021 to 2035*]. Ministry of construction, transport and infrastructure of the Republic of Serbia. https://www.mgsi.gov.rs/sites/default/files/PPRS%20Nacrt.pdf

[6] Statistical office of the Republic of Serbia. (2022, January 4). *Household income in money and in kind, by statistical territorial units (NTSU)*. https://data.stat.gov.rs/Home/Result/01010101?languageCode=en-US

[7] Mladenović, B. (2017). *Poverty in the Republic of Serbia 2006-2016*. Social inclusion and Poverty Reduction Unit of the Government of the Republic of Serbia. http://socijalnoukljucivanje.gov.rs/wp-content/uploads/2017/09/Poverty-in-the-Republic-of-Serbia-for-the-Period-2006-%E2%80%93-2016-%E2%80%93-Revised-and-New-Data.pdf

[8] Social inclusion and Poverty Reduction Unit (n.d.). Relative poverty. Government of the Republic of Serbia. Retrieved December 14, 2021. http://socijalnoukljucivanje.gov.rs/en/social-inclusion-in-rs/poverty-statistics/relative-poverty/

[9] Bogdanov, N. & Babović, M. (2014). *Radna Snaga i Aktivnosti Poljoprivrednih gazdinstava* [*The workforce and activities of agricultural holdings*]. Statistical office of the Republic of Serbia. https://pod2.stat.gov.rs/ObjavljenePublikacije/Popis2012/Radna%20snaga.pdf

[10] Gavrilović, D., Dodig Bukilica, D., Vulović, M. & Ćosić, J. (2021). *Regional Gross Domestic Product: Regions and areas of the Republic of Serbia, 2019*. Statistical office of the Republic of Serbia. https://publikacije.stat.gov.rs/G2021/PdfE/G202110115.pdf

[11] Bogdanov, N. & Babović, M. (2019). *Radna snaga i rad na poljoprivrednim gazdinstvima – stanje i trend, 2018* [*The workforce and work on farm holdings – trends and the state of affairs*]. Statistical office of the Republic of Serbia. https://publikacije.stat.gov.rs/G2019/Pdf/G20196006.pdf

[12] Trivić, N. (2019). *Zemljište; 2018* [*Land; 2018*]. Statistical office of the Republic of Serbia. https://publikacije.stat.gov.rs/G2019/Pdf/G20196003.pdf

[13] Paraušić, V., Roljević Nikolić, S. & Subić, J. (2019). *Poljoprivredna gazdinstva prema tipu proizvodnje i ekonomskoj veličini, 2018* [*Farm holdings according to production type and economic output, 2018*]. Statistical office of the Republic of Serbia. https://publikacije.stat.gov.rs/G2019/Pdf/G20196005.pdf

[14] Bevan, R. & Woolley, T. (2008). *Hemp Lime Construction: A guide to building with hemp-lime composites.* IHS BRE Press.

[15] Stanwix, W. & Sparrow, A. (2014). *The Hempcrete Book: Designing and building with hemp-lime*. Green Books.

[16] Škundrić, P. & Kostić, M. (2004). Renesansa konoplje u svetu i Srbiji [The renaissance of industrial hemp in Serbia and the rest of the world]. In T. Tadić (Ed.), *Konoplja-sirovina budućnosti [Industrial hemp the plant of the future*] (pp. 33-48). University of Belgrade Faculty of Technology and Metallurgy.

[17] Vasić, M. (2020, October 19). *Zašto Srbija ne koristi potencijal industrijske konoplje?* [*Why isn't Serbia utilising the potential of industrial hemp?*]. Talas. https://talas.rs/2020/10/19/zasto-srbija-ne-koristi-potencijal-industrijske-konoplje/

[18] Ministry of agriculture, forestry and water management of the Republic of Serbia. (2013). *Pravilnik o uslovima za gajenje konoplje* [*The terms for cultivating industrial hemp*]. https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/viewdoc?uuid=3b3726b3-ba02-4a9f-a5b8-f82be827ce8f

[19] Plant protection directorate (2021, December 23). *Lista priznatih sorti poljoprivrednog bilja* [*The list of recognized agricultural plant varieties*]. Ministry of agriculture, forestry and water management of the Republic of Serbia. http://www.sorte.minpolj.gov.rs/sites/default/files/rsprilogom_3.pdf

[20] Shea, A., Lawrence, M. & Walker, P. (2012). Hygrothermal performance of an experimental hemp-lime building. *Construction and Building Materials*, *36*, 270-275.

[21] Collet, F. & Pretot, S. (2012). Experimental investigation of moisture buffering capacity of sprayed hemp concrete. *Construction and Building Materials*, *36*, 58-65.

[22] Evrard, A. & De Herde, A. (2010) Hygrothermal performance of lime hemp wall assemblies. *Journal of Building Physics*, *34*(1), 5-25.

[23] Moujalled, B., Ait Oumeziane, Y., Moissette, S., Bart, M., Lanos, C. & Samri, D. (2018). Experimental and numerical evaluation of the hygrothermal performance of a hemp lime concrete building: A long term case study. *Building and Environment, 136*, 11-27.

[24] Tran Le, A.D., Maalouf, C., Mai, T.H., Wurtz, E. & Collet, F. (2010). Transient hygrothermal behaviour of a hemp concrete building envelope. *Energy and Buildings, 42*, 1797-1806.

[25] Ip, K. & Miller, A. (2012). Life cycle greenhouse gas emissions of hemp-lime wall constructions in the UK. *Resources, Conservation and Recycling, 69*, 1-10.

[26] Pretot, S., Collet, F. & Garnier, C. (2014). Life cycle assessment of a hemp concrete wall: Impact of thickness and coating. *Building and Environment, 72*, 223-231.

[27] Boutin, M.P., Flamin, C., Quintin, S. & Gosse, G. (2006). *Etude des caracteristiques environmentales du chanvre par l'analyse de son cycle de vie* [*Study on the environmental characteristics of hemp through the analysis of its lifecycle*]," Minstry of agriculture and food of the French Republic. https://www.ekopolis.fr/sites/default/files/2020-02/8%20chanvre_rapport_final_ACVd235d.pdf

[28] Amziane, S., Collet, F., Lawrence, M., Magnion, C. & Picandet, V. (2017). Part 1: Evaluation of initial water content and water absorption. In S. Amziane and F. Collet (Eds.) *Bio-aggregate Based Building Materials* (pp. 207-223). Springer.

[29] Ministry of construction, transport and infrastructure of the Republic of Serbia (2011*). Pravilnik o energetskoj efikasnosti zgrada* [*Regulations for the energy efficiency of buildings*]. https://www.mgsi.gov.rs/sites/default/files/PRAVILNIK%20O%20ENERGETSKOJ%20EFIKASNOSTI%20ZGRADA.pdf

[30] Ministry of construction, transport and infrastructure of the Republic of Serbia. (2012). *Pravilnik o uslovima, sadržini i na*činu izdavanja sertifikata o energetskim svojstvima zgrada [*Rulebook on the terms, contents and means of issuing certificates on the energy properties of buildings*]. https://www.mgsi.gov.rs/sites/default/files/Pravilnik%20o%20uslovima%20sadrzini%20i%20nacinu%20izdavanja%20sertifikata%20o%20energetskim%20svojstvima%20zgrada_0.pdf

[31] Van der Werf, H. (2014). Life Cycle Analysis of field production of fibre hemp, the effect of production practices on environmental impacts. *Euphytica 140*, 13-23.

[32] Nozahic, V. & Amziane, S. (2013). Environmental, Economic and Social Context of Agro-Concretes. In S. Amziane and L. Arnaud (Eds.) *Bio-aggregate-based Building Materials: Application to Hemp Concrete* (pp. 1-25). ISTE and John Wiley & Sons.

[33] Bogdanov, N. (2007). *Small Rural Households in Serbia and Rural Non-farm Economy*. UNDP. https://www.rs.undp.org/content/serbia/en/home/library/poverty/small-rural-households-in-serbia-and-rural-non-farm-economy.html

[34] Mitrović, M. (2016). *Problemi održivog ruralnog razvoja u Srbiji* [*The problems of sustainable rural development in Serbia*]. In], D.Kojčić, U. Šuvaković, D. Dević and B. Latinović (Eds.) *Sociologija Ruralnog Razvoja* [*The Sociology of Rural Development*] (pp. 581-603). Zavod za udžbenike.

1423 Broadway #1015
Oakland, CA 94612

510.452.9522

info@ecocitybuilders.org
www.ecocitybuilders.org