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Resiliency and Regeneration in the Pannonian Region of Hungary: Towards a Circular Economy

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Abstract

Using systems thinking and ecologically-reflexive planning, this study examines conceptual opportunities for resilience and regeneration of the historic northwestern Hungarian municipality of Kőszeg and its surrounding bioregion. It will explain how the town and bioregion's socio-cultural and socio-technical systems —its historic heritage coupled with existing and new industrial, commercial, and infrastructural services (energy, water, sanitation, waste)—can be placed into a regional development scheme that optimizes the vitality and resiliency of these collective systems, following the principles of a circular economy. This study assessed opportunities for Kőszeg, as one example in the region, to revitalize its economy and its local environment based upon attaining a high level of integration among its multidimensional resources. Conceptual strategies for practical solutions to town and bioregional revitalization and resiliency are discussed.

Keywords

Circular economy; Infrastructure integration; Resiliency; Bioregionalism; Closed-loop economy; Relocalization

1. Introduction

This research project assesses options for optimizing long-term sustainable growth within the rapidly changing Pannonian region located in western Hungary and formulates practical solutions to revitalization and resiliency of its rural and small city settlements.

1.1. Rural Townships in Transition

The twin phenomena of globalization and urbanization—an increasingly integrated planetary economy, and the absorption by metropolitan areas of most all our planet's population growth over the coming decades— are current subjects of scholarly focus. In contrast, relatively little attention has been paid to the associated demographic and economic decline of small towns and their hinterlands. In Europe, as in many other parts of the world, emigration to cities has generally weakened these rural service centers, causing many to stagnate, contributing to a loss of cultural heritage and associated social and economic values (Knox and Mayer 2013).

This is particularly true in Central and Eastern Europe, where, since 1989, de-collectivization and privatization processes have created new patterns of economic organization. These have contributed to rising unemployment and population loss in rural areas, loss of eco-system services, and diminished provision of public and private rural services (ECOVAST 2013). In Hungary, where rates of urbanization are projected at 82% by 2050 (UN DESA 2014), the revitalization and empowerment of rural communities through "relocalization"—place-based initiatives that include local environmental conservation and enhancement, job creation, food and water security, and transitioning to a post-fossil fuel economy (Longhurst 2015)—as speculated here, could begin to reverse this cycle of decline and abandonment.

1.2. Study Background

This notion of small towns as potential catalysts for sustainable and resilient rural development is the premise of a study undertaken as a pilot in the town of Kőszeg, Hungary (2017 population 11,747), which sits at the Austrian border in Vas county in the northwestern Pannonian region of the country. Kőszeg has been losing population, in part associated with the stagnation of the previous socialist economy as well as the ongoing out-migration of youth to the cities, and local labor to Austria.

Fortunately, many of the town's underutilized historic buildings have undergone adaptive reuse, some housing the Institute of Advanced Studies, Kőszeg (iASK). Affiliated with Pannonia University, iASK's mission is to study the current complexities and uncertainties in the Central and Eastern European region. Here, key research has been dedicated to fostering "creative and sustainable cities,"—in Hungarian the "KRAFT" initiative (Miszlivetz et al, 2012). The subject study grew from shared interests between iASK and the City University of New York (CUNY) regarding how the implementation of circular economy practices in such towns and even regional cities might reverse these trends. A research team comprised of faculty and students from CUNY and affiliated Hungarian universities spent a month assessing opportunities for revitalizing Kőszeg and its forested and agricultural bioregion, investigating its assets and extrapolating potential outcomes from the application of such sustainability principles and practices to this township.

1.3. Methodology

For this interdisciplinary project, researchers worked in four teams (three or four students each), focused on hydrology, forestry, agriculture, energy, and economic development to determine a base case and propose actionable alternatives. Sustained interaction and information-sharing across the teams led to collective solutions based on integration and exchanges across these natural and socio-technical systems. For the former, various modeling tools were employed, including the Soil and Water Assessment model (SWAT) to examine short and long term hydrologic impacts and LANDSAT to determine forest cover changes. Given that closed-loop systems prioritize a more sustainable use of inputs and waste-recycling potential from the biosphere, it is critical to understand the limits of ecosystems and their historical climate in supplying the human systems with what are ultimately unpaid-for services. SWAT was therefore also used to classify agricultural crops towards quantifying potential waste outputs for recovery and use.

Evaluation of the town's economy considered its commercial sector, tourism, recreational assets, and underutilized historic building stock. By diagramming and quantifying potential flows from each of the four sectors, strategies were developed to recover and utilize many existing waste streams (water, energy and nutrients) in a proposed new "Eco-Innovation Center (EI Center)," a modest and practical incubator of circular economy philosophies.

1.4. Circularizing Kőszeg's Natural and Economic Resources

At the outset, it was determined that the optimal study boundary would be defined by the Hungarian-side of the watershed of the Gyöngyös River sub-basin, a year-round body of water flowing out of Austria and into Hungary from the northeast, through Kőszeg and extending South towards the neighboring city of Szombathely (pop. 78,000), see fig. 1a. Within this boundary, existing conditions for each of the four sectors were assessed, and cross-cutting interventions proposed as follows:

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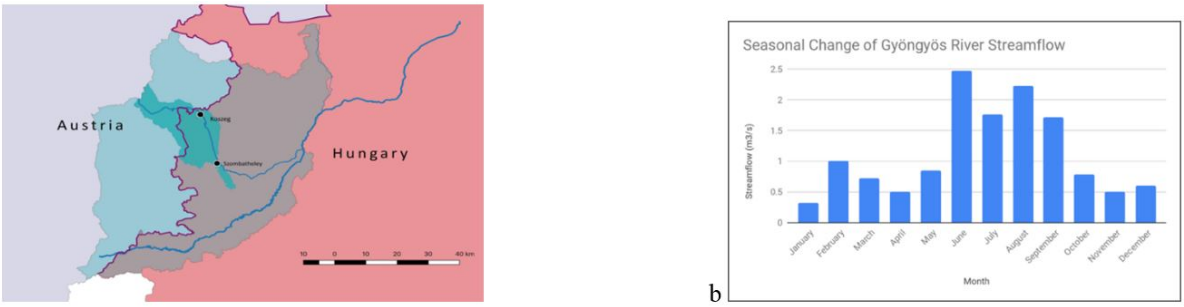


Figure 1. (a).Location and Study Boundary (b)Seasonality in Gyöngyös River Streamflow Excess

2. Water Sector

The study attempted to evaluate existing hydrologic patterns and examine issues related to Kőszeg's dependency on nearby Perenye's water filtration and Szombathely's water treatment plants. First, an understanding of the regional water baseline was created using SWAT modeling (fig. 1b). Second, the team evaluated Kőszeg's exposure to flash flooding due to strong seasonality of precipitation and streamflow as well as a projected increase in intensive rainfall in a changing climate. Floodwater emanates both from the Gyöngyös' overtopping its banks, as well as from creeks and gullies in the adjacent Kőszeg hills channeling debris and sediment flows into the town itself during major events.

Mitigation of the Gyöngyös overflow is a key objective and led to a conceptual design for a new holding pond and constructed wetland (8,000 cm capacity) upstream from the river's entry to the town (see fig. 2). This would be engineered to regulate, retain and treat excess surface water and return it downstream. Biofiltration conducted in the wetland cells would mitigate pollutants, rendering the water cleaner for various uses, including downstream swimming, thereby reviving the town's "beach"—a valued community recreational asset now closed. Improved forestry practices and increased vegetation cover could remediate the debris and sediment downwash caused by forest cutting, and check-dams could reduce sediment flow from the creeks and gullies into the town (Veress et al, 2012).

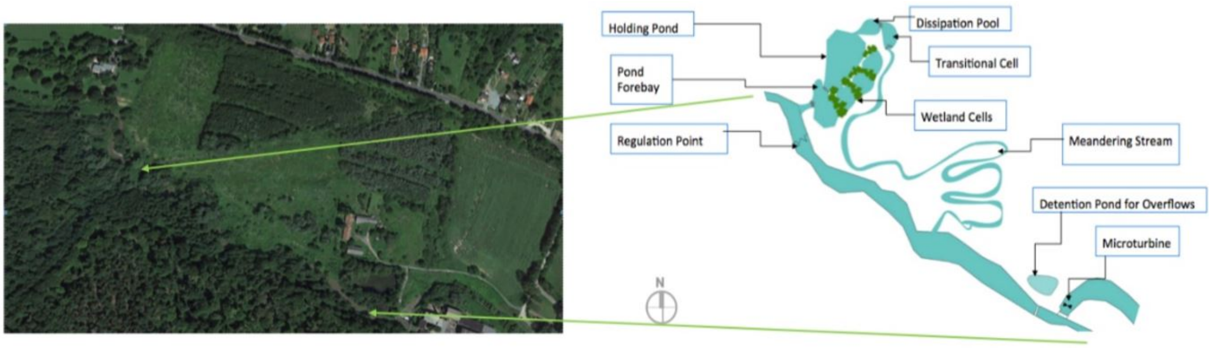


Figure 2. Gyöngyös Proposed Wetland: Aerial view (Google Earth) and Conceptual Plan

Finally, it was recognized that the legacy systems operated by municipal utility providers in Perenye and Szombathely that currently provides Kőszeg's water services—potable water, sewerage and stormwater treatment, would not be feasibly modfied at this time.

The Eco-Innovation Center, however, would be one specific location where water recovery and reuse would take place (see section 6.). Greywater, recovered and treated, from food-production, coupled with harvested- and cister-stored rainwater, could be utilized for non-potable uses on site. Water wastes from the proposed new brewery would be valorized, along with local organic waste, in an on-site anaerobic biodigester. Anaerobic digestion is a promising technology that can transform these wastes into a highly energetic biogas. Nutrient rich water in the form of a slurry, a biodigestion byproduct, provides fertilizer for local crops.

3. Forestry and Agricultural Sectors

An assessment was conducted of agricultural and forestry resources to better understand their relevance to a circular economy for Kőszeg. Besides circularity, the issue of a more environmentally-friendly, and sustainable forestry practice—one that takes biodiversity and microclimate changes into account—has been considered throughout the research. The studies utilized Google Earth engine to process the Global Forest Change 2000-2014 data set derived from LANDSAT imagery and European Space Agency (ESA) Sentinel-1 data to assess land cover change (Hansen et al, 2013). The study area comprised approximately 1,260 sq. km, of which roughly 60 percent is currently land under crop and viticulture cultivation. The other 25 percent is forest cover predominantly in the sub-alpine hills bordering Austria.

The forests are comprised of a mixture of secondary growth spruce, pine, oak, and beech. A portion of the wood harvest is exported to Szombathely for industrial processing, from which Kőszeg obtains revenue, while the remainder is collected as fuel for both primary and auxiliary domestic heating in Kőszeg. The Kőszeg mountains public forest area (5,250 ha. on the western side of Gyöngyös watershed, fig. 3a) is considered to be sustainably managed according to existing local regulations. However, the area has experienced a net 2.8 percent loss between 2000 and 2014 (Hansen et al., *Science* 2013). The area reveals some broad clear-cut areas, one as large as 5 hectares, which have likely contributed to the erosion, streamflow and debris downwash mentioned under section 5.1 above. These open areas may also effect the regional climate by producing unusual wind waves. Replanted regions usually include high value stands, though non-native species, such as pine are regrown as well. Increasingly, more resilient species such as oak are planted. On the east side of Gyöngyös watershed (fig. 3b.), the dispersed, privately-managed forest areas also indicate a checkerboard pattern of clearcutting. These forest areas and are known to be relatively less well managed, perhaps attributable to the fact that these tracts are largely under shared ownership. Nonetheless, this area has sustained meaningful regrowth with only a .86 percent net loss during the same 2000-2014 period.

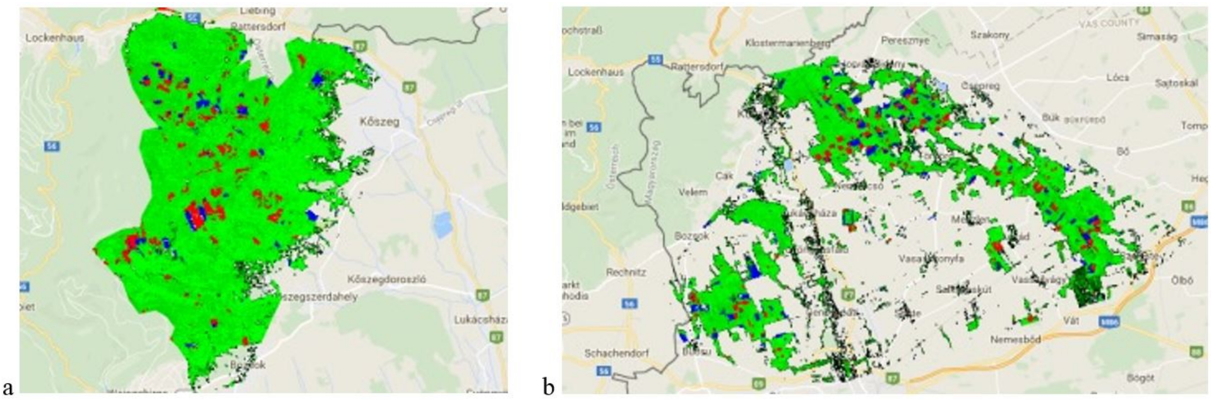


Figure 3. (a) Net Forest Change, Western Watershed (b) Net Forest Change, Eastern Watershed

To improve forestry methods and increase biodiversity in both the eastern and western watershed, it is recommended that Kőszeg initiate discussion with Szombathely and private land holders regarding the adoption of the European Pro Silva method of management based on natural processes, mixed age trees, and constant afforestation and reforestation (Duncker et al, 2012). In the long run, selective cutting (Pro Silva method) is more profitable, because the clear-felled forest requires longer years of care and work to grow back. Pro Silva utilizes forests in such a way that takes the local soil and biodiversity into consideration. Pro Silva can serve as the one method that is sustainable and provides for the industrial needs of Kőszeg region. Reforestation practices should include consideration of the species most resilient to regional climate change. Given the increasing summer aridity, there may be an opportunity to plant higher value, higher quality trees, such as red pine and oak, that have greater resilience against climate change-related conditions and associated insect infestation (Gyurácz et al, 2008).

Agriculture practices in Hungary in general changed after 1990. The nation transitioned from collective farms to industrial-scale, privately-held farms coupled with medium-sized and small local producers who supply domestic/international and local markets respectively. The agricultural economy is dominated and largely controlled by national integration companies that manage domestic and international sales and provide necessary inputs (seed, fertilizer, pesticides, etc.) to the farmers. Farming in general is state-subsidized (see fig. 4a).

In line with the sharing and circular economy, however, an alternative model for small and medium farmers, considered here, would be more efficient at the same time it could enable growers to earn higher profits. The proposed cooperative model (fig. 4b) is based upon one that has been effectively utilized by local Kőszeg wineries, which share relevant information, tools, and labor. In lieu of the for-profit intermediaries, a district-based not-for-profit organization would provision and inform small and medium producers, and pass products to a regional not-for-profit integrator supplying local, domestic and international markets. These integrators would forego, or take a radically-reduced profit, enabling an increase to farmers' revenues. The state would be linked to all the economic operators in the form of both taxes and subsidies. In addition, there would be a more direct supply line from the small and medium producers directly to local markets.

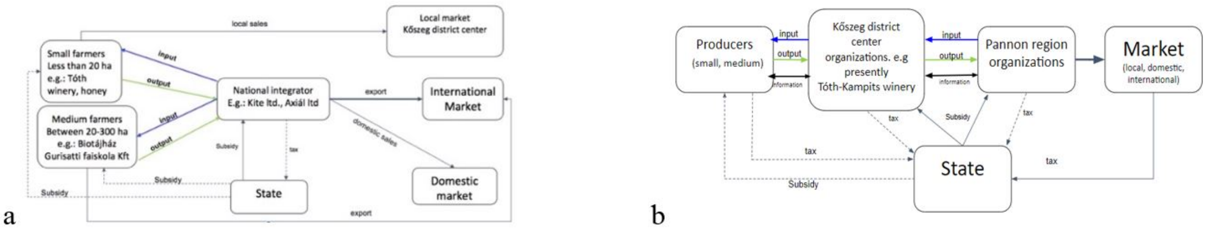
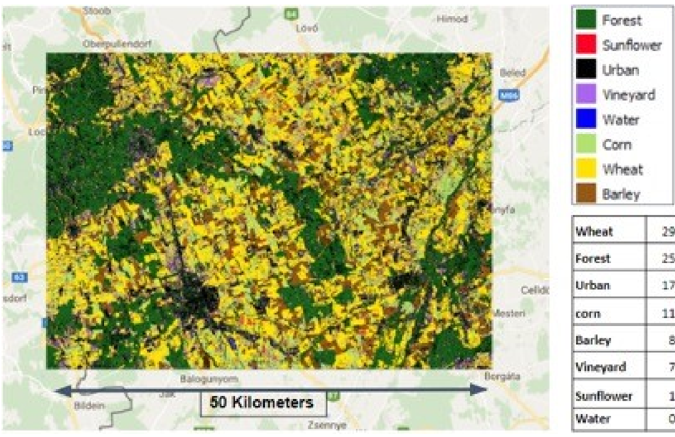


Figure 4. (a) Diagram, Current Agricultural Economy Model (b) Proposed Cooperative Model

A comprehensive agriculture assessment of the area, with statistical crop- and economic data was unavailable for the study area. Instead, high resolution Sentinel-1 monthly-averaged radar images for the period of June 2017-May 2018 were utilized to classify and quantify lands in production in order to understand potential outputs from cropland and viticulture (fig.5.). Subsequently, targeted site visits provided training data for the Maximum-Likelihood-Classification. The most important arable crops are wheat, corn, autumn barley, spring barley, sunflower, autumn cabbage, rape, and soybean. The extent of arable land in Kőszeg is not considered significant due to terrain conditions and the unusual level of forest coverage compared to the national level. According to the National Land Registry Information System Takarnet database (http://www.takarnet.hu/), 60% of the administrative area is forest, 15% arable, 5% orchards, and 1% grapes. The arable lands, mostly in private hands, are considered of medium fertility. Therefore, Kőszeg and its micro region should not be considered a significant supplier of grain and fruit to Hungarian food wholesale trade.

The portion of the agricultural waste (agro-waste) produced in this area that is not tilled under (a relatively low percentage) provides a viable opportunity for valorization. This would include bio-energy and bio-fertilizers from anaerobic biodigestion. Local agro-waste recovery strategies are also being considered for the Eco-Innovation Center, which will be dedicated to eco-efficient products. In addition, agro-waste from cereal crops may be upcycled into building products (Madurwar et al, 2013), for example, sustainable building insulation, and particle board (see section 5.1).

Kőszeg belongs to the wine region of Sopron, with its excellent vineyards and wine cellars. The two most important wine making companies are Tóth Winery, and the Kampits Family Cellar. On average, the vineyards are relatively small in size, between 5 and 10 hectares. The practice of applying grape waste directly for vineyard fertilization should be considered a circular practice. Therefore, for the Kőszeg economy, local land-use policies should preserve and possibly enhance the wine traditions and wine culture, thereby promoting local and cross-border trade and wine tourism can be a factor for development.



Wheat	29.30%	51654 ha
Forest	25.40%	44778 ha
Urban	17.50%	30851 ha
corn	11.00%	19392 ha
Barley	8.00%	14103 ha
Vineyard	7.50%	13221 ha
Sunflower	1.30%	2292 ha
Water	0.10%	193 ha

Figure 5. Categorization of Agricultural Areas and their Outputs by Modeling

4. Energy Sector

In conducting an assessment of the energy sector and the role it could play in a circular economy, the objectives included addressing current sectoral challenges, examining untapped local resources, and considering opportunities for recovering local wastes for energy production. As a land-locked nation, Hungary lacks sufficient domestic power sources of fuel. The bulk of the country's energy mix (58 percent of the total primary energy supply) relies on crude oil and natural gas exports from Russia. Hungary's single Paks nuclear power plant provides 16 percent and 11 percent is derived from biofuels (Aracuba Editor, 2017). The European investor-owned electric utility service, E.ON Hungária Zrt., supplies electricity and gas to customers in the Transdanubian region. Household energy consumption per household is estimated to be 17MWh annually; electrical consumption was estimated to be 2.65MWh per household annually; and heating demand was estimated at 13MWh per household annually (Eurostat 2018; Heat this are still below other EU national targets. Despite the fact that the country is endowed with good solar irradiance, plentiful biomass and geothermal energy potential, the proportion of renewable sources has declined recently (Szo, 2018). As of 2016, new regulations hinder the penetration of new wind energy (IEA 2017). Given the reliance on limited sources of primary energy, long-term grid resiliency is an issue for Hungary's energy infrastructure.

Another challenge is that of problematic practices in home heating (see fig. 6a). In addition to use of natural gas, many Hungarians rely upon burning of wet, low quality fuel wood and domestic waste in home stoves as an inexpensive supplement or alternative to gas purchases (Lenkei, 2016). In winter, poor air quality resulting from particulate emissions has created national health impacts. The OECD cited 937.6 deaths per million inhabitants in Hungary in 2010 due to ambient particulate matter and ozone pollution, just shy of the rate of China (McCarthy, 2016).

For the purposes of this project, improvements were proposed for heating and electricity in the residential sector with specific innovations to be showcased at the eco-innovation center. A general transition to locally-based, renewable energy sources is envisioned in both cases. Accordingly, an assessment of energy potentials was undertaken for improved wood-burning practices, solar, hydro-power, and anaerobic biodigestion potential of the region.

The effective curing and storage of wood fuel is well aligned with sustainable forestry practices. The provision of drying zones/storage areas in dedicated, in-town vacant structures, as part of an energy cooperative, coupled with incentives for upgrading to high efficiency stoves, and governmental monitoring of trash-burning, could reduce wintertime emissions of water vapor, soot, dioxins and other noxious substances.

Given the plentiful solar irradiance in Kőszeg (1200 to 1240 kWh/m^2), solar energy utilization, in the form of both photovoltaic arrays and solar thermal heating, is a first priority. Rooftop arrays could be retrofitted onto an estimated 30-40 percent of building roof areas (excluding historic buildings and adversely-sloping roofs). Additionally, the application of solar thermal panels could supplement domestic water heating. At the proposed eco-innovation center, roof-mounted solar panels (with battery storage) and solar thermal arrays were calculated to cover the center's basic electrical loads (excluding process loads).

Micro-hydro is another option. In recent past, the Gyöngyös river, was partly diverted through an auxiliary canal paralleling the river through town that once powered several mills. During the socialist era, hydro-electricity was also produced at a dam located at the entrance to the town adjacent to underutilized factory buildings, now the proposed location of the Eco-Innovation Center. The Gyöngyös has a discharge rate of 1 cubic meter per second, and a 2-meter head, resulting in an average power capacity of about 20 kilowatts. It could accommodate a series of micro-hydro turbines adjacent to the factory to provide supplementary renewable power. An estimated annual energy production is ~ 130 MWh per turbine, based on a seasonally varying discharge rate.

Lastly, local valorization of another renewable fuel, biomethane, is under consideration as a supplementary means to achieve a measure of electrical resiliency. A large-scale pig farm operating in the vicinity of Kőszeg provides one such source. The farm's annual manure output of 24,000 liquid $m,^3$ would, if recovered, yield 35,895m^3 of biomethane. Valorization of this fuel, together with recovery of the currently flared 26,280 m^3 of methane sourced from the municipal waste-handling facility, could technically generate 77 and 56MWh of electricity respectively. Biogas would be additionally produced at the Eco-Innovation Center. Biodigested waste from a proposed micro-brewery, (2,000 beer barrel annual production capacity) annually would yield 217,000 gallons of wastewater and 2,5000 tons of spent grain that would produce an estimated 194,000 m^3 of biogas annually, equivalent to 414.5MWh of electricity. The residual slurry would be dedicated to local crop fertilization. At the EI Center, the biogas would be utilized for cooking at proposed gastronomic facilities (e.g. bakery and restaurant). Finally, the visible application of a selection of these renewable energies at the Eco-Innovation Center is an opportunity to demonstrate and de-mystify renewable energies and encourage public support to further projects (see fig. 6b).

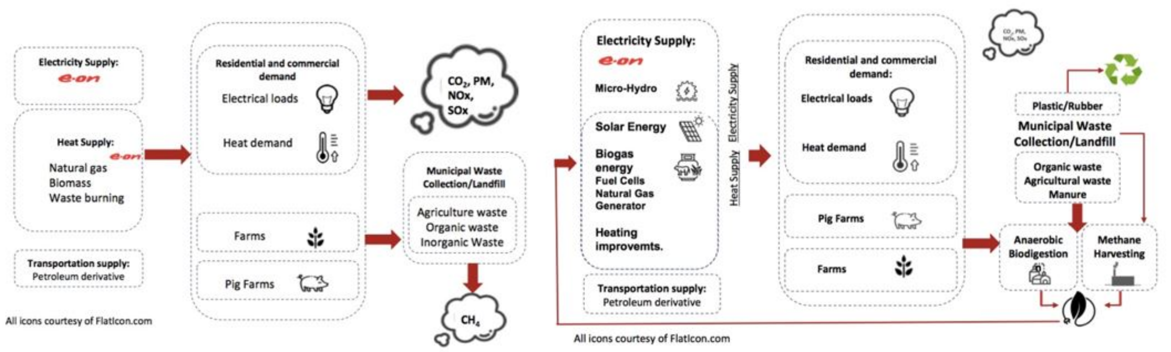


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Figure 6. (a) Diagram of Existing Energy Flows (b) Diagram of Proposed Alternatives

5. Economic Development

Optimized by partial re-design, an integrated and linked system of natural resources, goods and services can begin to replace a "once-through" economy with a circular one.

5.1. Connecting the Assets

Kőszeg has a multitude of cultural, historical, natural, and physical resources at its disposal as a result of its geography and history. Much of its central building stock date back as far as the 16^{th} and 17^{th} centuries, while its castle and (remaining portions of) its encircling town wall date from medieval times. The town boasts of multiple museums, plazas and historic monuments, not only centrally, but also has places of interest in the Kőszeg hills and nearby villages which feature geothermal spas. The town sponsors multiple festivals annually, around the city's history, culture or local products, for example its unique viticulture. Since the 19^{th} ct., it was also know as a "City of Schools," with multiple acadmies, iASK, a campus of the University of Pannonia, as well as vocational training centers. Lastly, the surrounding forests (territory conserved by the Hungarian Nature Park Systems) host a multitude of recreational resources: hiking, biking and nature trails, and three artificial lakes in the vicinty. Tourism therefore (90% from Hungary, 10% from Austria) constitutes a critical part of Kőszeg's economy, effecting day-to-day town life (Kukely, 201). Research suggests that growth in this industry would be best accommodated through ongoing adaptive reuse of under-utilized historic buildings in the town center.

Local infrastructure paints a less impressive picture, however, with infrequent train links to nearby Szombathely. There is fair inter-municipal bus service, but road conditions, as well as bike and pedestrian infrastructure, are sub-par: narrow and not well-maintained. Despite these weaknesses, there is great potential for improving Kőszeg's economic and environmental outlook, and many resources exist which can be leveraged.

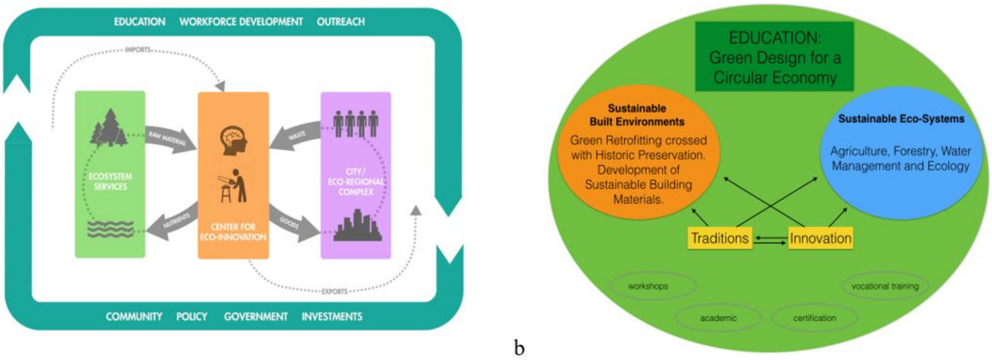

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Figure 7. (a) Circularity Diagram -Kőszeg Center for Eco-Innovation (b) Proposed Educational Programming

5.2. The "Kőszeg Center for Eco-Innovation"

Located at the northeast edge of town in an underutilized early 20^{th} ct. factory complex, part of which houses a roofing felt and felt craft enterprise, the EI Center will help launch and support creative businesses by providing labs and work space, business skill training, and access to financing and professional networks. It will serve as well as collaborative community workspace. Using Kőszeg's sustainably harvested forestry and agricultural resources, the EI Center's new entrepreneurs can test new technologies and develop new ideas. It would also offer workshops, galleries, tours and open lab space to visitors.

Three main components are included in the EI Center (see fig. 7a). The first in the Eco-Enterprise Center & Lab, which is dedicated to fostering the local market for sustainable building products, many fabricated from local biological and technical waste streams (e.g. "wheatboard" and particle board, reclaimed wood products, etc.). It would include salvaged local waste materials, including decorative building elements recovered from historic buildings undergoing retrofits. In addition, sustainable handicrafts, using similarly local inputs, would complement the mission of the craft work of the existing "Multifelt" felt factory. This lab would offer hands-on learning through internships and workshops with local schools, (see center box, fig. 7b).

A second enterprise, a "gastro-tourism" venue, would incubate businesses dealing in local and sustainable food products using sustainably grown crops from Kőszeg's farms, orchards and vineyards. It would include a micro-brewery, a bakery that uses locally sourced grains to produce beer and baked goods for sale to both tourists and the Kőszeg community. The gastro-tourism enterprise would also include on-site aquaponics and soil-based green-houses, which could contribute additional ingredients or products to be cooked or sold on site: fresh fish, tomatoes and leafy greens. Finally, the enterprise would coordinate an on-site farmers market, where locally and on-site produced agricultural and culinary products could be sold directly to the Kőszeg community and local tourists, creating visibility and economic opportunity for farmers and the gastro enterprise while supporting a mission of local food production (see center box, fig. 8).

Lastly, the EI Center would feature a showcase of, and potential showroom for, sustainable energy and infrastructural products, for example, solar thermal panels, small scale micro-hydro turbines. It would feature the operations of the facility-specific anaerobic biodigester, as well as models that might be utilized by organic farmers. In addition, small scale biodiesel processors could be incorporated to capture used cooking oil for conversion into a clean substitute for diesel fuel, which could power food trucks or other vehicles used to transport goods on site or to local distributors. Finally, the site will utilize and demonstrate regenerative strategies for water management. In addition to on-site rainwater harvesting, it will feature "bioswales" that clean and infiltrate stormwater, and promote local use of cisterns and products such as grass pavers or porous pavers, and other landscape elements that promote water retention or infiltration (see fig 8.).

In summary, the EI Center would serve as a venue where local products could be showcased and a place for the public to learn about the workings of a circular economy. It would demonstrate the ideas of "loop closing" and regenerative/ restorative design at many scales, from the food-waste-to-energy loop on site to the idea of upcycling textile waste from the Kőszeg region into sustainable building products. It would be a destination for visitors and locals alike, and a beacon to draw attention to the possibilities inherent in circular economy thinking, increasing tourism and driving economic growth for Kőszeg.

In addition to creating educational and economic opportunity, the site would demonstrate the principles and technologies of green energy and infrastructure that are espoused by the project enterprise. Calculations performed show that there is ample potential for the site to be powered by rooftop solar and micro-hydro power as shown. In addition, anaerobic digesters located behind the culinary center would power the cooking facilities while treating the waste. Finally, the site would incorporate rain barrels for harvesting rainwater, permeable paving, and a series of decorative yet functional infiltration basins that would collect and clean rainwater during storm heavy rainfall events.

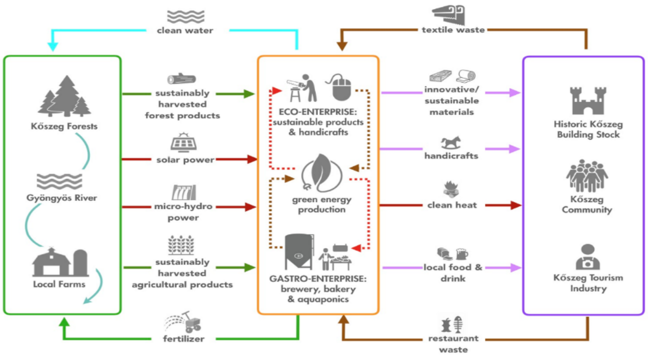

Figure 8. Diagram of the Eco-Innovation Center's Internaland External Resource Flows.

Figure 9. Rendering of Kőszeg Eco-Innovation Center

5.3. The Kőszeg Center for Eco-Innovation in Context: A Master Plan

A contextual master plan for the EI Center (see fig. 9) expands upon Kőszeg's existing natural and physical assets: the town's historic fabric (considered the "Jewel Box of Hungary"), the channeled but still romantic Gyöngyös River, the Kőszeg forest with its trail system, its natural bogs, and historic monuments and the town's array of educational facilities and under-occupied building stock, all loosely connected along the Gyöngyös river's spine. Executed across multiple phases, the plan would integrate these resources with upgraded, sustainably oriented infrastructure (green color) to better serve an expanding local and tourist population. It links key features educational features (blue color) with the proposed Eco- Innovation campuses—one planned downstream in future,(orange color)—to stimulate further economic growth across all sectors of the economy.

The Gyöngyös River constitutes the organizing element of the proposed master plan (see fig 9.). Originating in Austria as the Güns River, the Gyöngyös crosses the border and continues downstream for almost 50 kilometers until it joins the Raba River. The narrow river basin connects several key recreational resources in Kőszeg, including the Boating Lake and Lake Abért, and accommodates the (discontinuous) biking and walking paths that connect to Kőszeg's historic district and regional trail system. The Gyöngyös is not currently a primary tourist destination in Kőszeg, but offers great potential as an integrating spine for all its attractions, connecting several disused mills, parks and miscellaneous structures that have redevelopment potential and scenic value.

While many well-used paths and green spaces exist in Kőszeg, they are fragmented and in need of upgrade. Over time, the connection of existing and new pedestrian and bike pathways along the river and through the town would create better access to existing physical, cultural and natural amenities, linking citizens to the proposed educational programs at the EI Center. Improvements to the bike lanes, current riverside park areas, and pedestrian pathways would promote beneficial access between the new intermodal transit station planned for the southern end of town, the town center, and north to the EI Center campus, also linking to the important regional trail networks that have important tourist value, including the Iron Curtain bike trail that runs along the Austro-Hungarian border, the European Long Distance Walking Route E4 and the Alpannonia trail network.

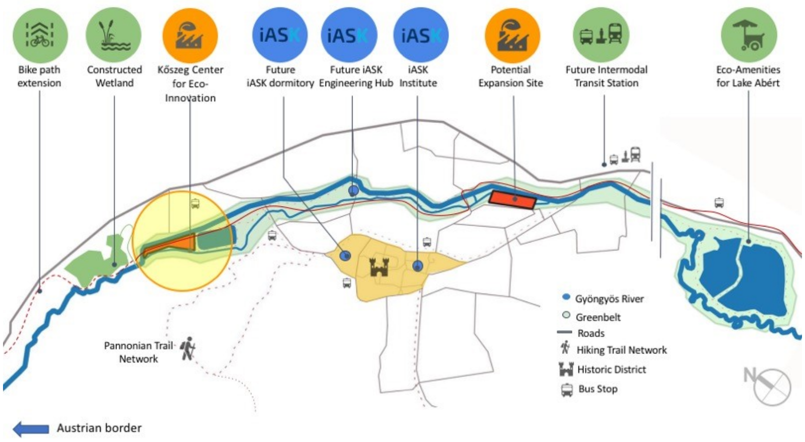

Figure 10. Conceptual Master Plan Showing Education, Innovation and Infrastructural Improvements

6. Conclusion

This interdisciplinary inventory of natural, historic, industrial, and commercial resources identified the critical features of the town's and bioregion's asset pool that could be integrated, internalized, and thereby "circularized"—within a boundaried setting. Potential benefits include: a reduced need for imports of more costly energy, materials and services; job creation and training of a next generation workforce around sustainability principles; wealth-building by attracting regional and even foreign investment in these future-proofing enterprises; and a network for business development in state-of-the-art renewable materials and energy technologies. The resultant master plan supports a resilient and future-thinking Kőszeg that may entice young people and families to stay. As a demonstration project, the Kőszeg Center for Eco Innovation intentionally models the possibilities of a circular economy and has the potential to launch a movement towards these practices that extends to the surrounding region and beyond.

7. Acknowledgments

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