CIRCULAR ECONOMIES FOR RURAL RENEWAL: REVITALIZING TOWNS AND THEIR BIOREGIONS

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ABSTRACT

Worldwide urbanization, a phenomenon affecting both industrialized and developing nations, has been significantly sustained by decades-long draining of population from rural towns and their outlying bioregions. Small town shrinkage, particularly loss of youth populations to cities, is both symptom and cause of ongoing rural economic, social and cultural marginalization. Reversing this trend will require new ways of thinking about these devitalized human settlements. Detailed here, one alternative relies on an emerging, locally applied holistic model known as the circular economy. Grounded in systems-thinking, a circular model fosters closed-loop cycling of natural, constructed, and human resources to spur more resilient economic development. Arguably, such a challenging systems remodelling could be more readily managed at the town versus the city scale. That premise was behind the key project objective: modelling a circular economy in a conceptual plan developed for a small historic town, Kőszeg, in north-western Hungary, one that could serve as a prototype for the region and beyond. Research and plan development was undertaken by an interdisciplinary student team tasked with identifying practical, cross-cutting strategies involving the natural, the constructed and the economic sectors. These included: (1) proactive renewal and diversification of local resources – regional ecosystem services as well as complementary methods of greener food and fibre production; (2) potential introduction of alternative resilient, low-impact infrastructural services – power, sanitation, water and waste management; and (3) economic diversification through development of innovative, closed-loop enterprises, along with enhanced tourism grounded in cultural heritage and regional recreational offerings. The outcome was a collaboratively fashioned circular economy model highlighting cross-sector synergistic opportunities. As an interdisciplinary undertaking, the Kőszeg study demonstrates both the circular framework's utility along with some of its challenges. Its methodology may have application for other rural settlements in decline.

Keywords: circular economy, rural revitalization, resiliency, decarbonization, interdisciplinary collaboration.

1 INTRODUCTION

With 68% of the world's population expected to live in cities by 2050, urbanization is inexorably sweeping planet Earth. Developed nations are leading the way. 82% of North Americans are living in urban areas, followed closely by Latin America and the Caribbean (81%), with Europe at 74%. Losses are particularly pronounced in parts of Eastern Europe with the shrinking of rural regions by 80% between 2001 and 2011. For Europe, going forward, poor prospects exist for rural regions: whereas urban regions stand to add 24.1 million individuals by mid-century, rural regions will decline by 7.9 million [1]. Formerly thriving towns of southern Europe, Portugal, Italy, Spain have emptied out. In Italy in 2015, as many as 15,000 villages had been reduced to 10% of their population, with 6,000 of these now considered ghost towns [2], joined by 2,900 in Spain [3]. The same issue exists in the US; while 97% of the US's land mass is considered rural, it is occupied by only 19.3% of Americans, in 2016, down from 44% in 1930 [4].

Rural depopulation and marginalization of town and rural regions has been considered the new normal [5]. With cities serving as hubs for social and economic advancement, outmigration of both youth and the better-educated depresses rural economic conditions,

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inviting in poverty. In the US, for example, the rural poverty rate was 16.4% vs. 12. 9% for cities [6]. Particularly at risk are small farmers.

The restructuring of agriculture and its industrialization has triggered a series of problems. Abandonment of smaller, traditional farming and animal husbandry practices has encouraged ecological degradation – encroachment of shrubs and grasses, decreasing biodiversity, and increased risk of fire [7]. Also, mechanized agriculture not only fosters a net loss in the diversity of local food products, it also vastly reduces the need for manpower, further undermining rural employment.

Rural population shrinkage contracts the economy and reduces local quality of life. It induces a loss of the local tax base and diminishes local government spending for infrastructure, public services, and schools. Rural flight also deflates property values, often leaving the elderly marooned as young people depart for cities. In a vicious cycle, net losses undermine local businesses and town development capacity, prompting further abandonments.

With the decline of the hinterland, at risk is more than regional ecosystems and economies – local food and material resource production. Rural activities have, and continue to co-produce a "cultural landscape" – one with spatial, visual, and symbolic importance, both ordinary and extraordinary [8]. The ancient man/nature interdependency has produced a rural way of life, traditional values and local heritage, key to maintaining regional and national identities. Innovative thinking is required today to address the demographic, economic and cultural plight of these declining rural settlements.

2 DEFINING THE CIRCULAR ECONOMY

Sustainable development literature has recently embraced the term as a progressive vision and advanced policy agenda. Focused on resource decoupling and the green economy, the circular economy posits that cities exist in an environment of constrained resources. Cities receive inbound flows of energy and matter from the hinterland, and eliminate waste through export and assimilation into same. The circular economy model attempts to counteract the ecological and socio-economic imbalances of this linear model [9]. Its core principle mandates reliance upon renewable energy sources and the creation of non-linear flows, i.e. recursive loops – recovering and reusing resources. In other words, waste output from one system becomes input to another. The circular economy builds on the scientific approach of industrial ecology – the study of biophysical stocks and material and energy flows – with the objective of creating closed loop processes. This strategy reduces overall environmental pressures and reliance upon on virgin resources, while lowering systemic material and energy cost.

A universal objective of the circular economy is to spur participants in the resource value chain to extract optimal use from both existing products and processes as well as the elements they contain and energy they consume [10]. Internal manufacturing and external consumption practices are reconfigured to promote reuse, recycling and waste elimination for an economy that is more restorative by design.

3 AMPLIFYING THE CIRCULAR MODEL FOR REVIVING RURAL ECONOMIES

How might the framework of the circular economy – today largely defined for and applied to manufacturing and industry in urban economies – proffer opportunities for holistic revitalization of the town/bioregion? The circular model, proposed as outlined below, was designed for application to a declining small town and its rural economy. The assumption was that at this more manageable scale, it could be evaluated more inclusively and

interactively, assimilating into the circular model the workings of local infrastructure, bioregional natural capital, and agriculture.

This holistic approach was applied in a study conducted in the historic north-western Hungary municipality of Kőszeg (2017 population 11,747) inclusive of its surrounding bioregion, known as "Pannonia". The study was envisioned as an response to current conditions: a stagnant, post-Soviet bloc agglomeration economy in the Pannonian region that is generally dominated by large-scale, industrialized agriculture and forestry. Kőszeg provided a theoretical test-bed for applying circular economy concepts to revitalize its economy and its local environment predicated on attaining a high level of integration among its multidimensional resources – its historic heritage coupled with existing and proposed new industrial, commercial, and infrastructural services (energy, water, sanitation, waste) as well as its local forestry, farming, viticulture and animal husbandry.

The interdisciplinary study objective was to identify place-based, cross-cutting initiatives that would enhance environmental conservation and regeneration in the immediate bioregion, while creating new jobs, improving food and water security, and promoting a transition to a post-fossil fuel economy. The study methodology, conceptual strategies, together with proposed practical solutions to town and bioregional revitalization and resiliency are described below.

4 STUDY METHODOLOGY

The subject study grew from shared interests between the leadership of the Institute of Advanced Studies, Kőszeg (iASK) and the author, a City University of New York (CUNY) professor, regarding how the introduction of circular economy paradigm in settlements might reverse the settlement's downward trends. An research team, comprised of faculty and 14 interdisciplinary graduate-level students, half from CUNY and half from iASK-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 a circular economy model and sustainability practices to this township. Initially, one study team with engineering and science expertise explored area hydrology and water issues. Another, with engineering and forestry backgrounds addressed local heat and power. A third team, those studying agronomy, ecology, economics and biology examined the immediate region's agriculture, forestry and viticulture. Those with backgrounds in architecture, planning and social science focused on Kőszeg's economic and cultural assets. With the project's emphasis on cross-cutting synergies, data analysis and research findings were shared iteratively across the whole group.

A number of students, the Hungarians in particular, were conditioned to specialization within their own discipline, and initially were skeptical of cross-disciplinary collaboration. However, by facilitating their interaction, coaching them in the practice of "relational thinking", grouping and regrouping them according to the linkages they started to find, their confidence in the integrative design process increased. Gradually most all came to embrace the methodology of planning for systems integration.

Collectively, the team defined the optimal study boundary as 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 (2017 population 78,000) (Fig. 1). In order to assess the feasibility of an integrative bio-economy model for Kőszeg's public services and local industry/agriculture, the initial assessment entailed a combination of on-line research, articles and data collection, use of remote sensing (radar-based classifications) and other modeling tools – here, some specialization was required. Everyone worked to assemble maps at multiple scales, and all

worked across their disciplines to develop diagrams of the interrelated resource and energy stocks and flows. Most participated in all field observations. Local knowledge was captured through access to, and discussions with, public officials, non-profits, public, and privately owned companies, and key academics.

Figure 1: Location and study boundary.

5 INTERDISCIPLINARY STUDY FINDINGS AND PROJECT RECOMMENDATIONS

A circular economy model for Kőszeg was designed to demonstrate more holistic ways of approaching endogenous rural development by applying more innovative, sustainable and place-based strategies. The diagrammatic model (see Fig. 5) that was developed focused on regeneration of local and bioregional ecosystem services, including new means of food and fibre production; incorporation of more resilient, low-carbon, low-impact infrastructural systems; and the promotion of economic diversification based on innovative recovery and use of local wasted resources.

5.1 Improving water systems' resiliency

Adverse effects from agricultural runoff and seasonal flooding in Kőszeg's sub-alpine mountain surroundings, exacerbated by increasing climate instability, were assessed using satellite modeling: SWAT (Soil and Water Assessment Tool). The model helped predict how a changing climate might affect the hydrologic performance of the watershed. The area's flash flooding into gullies and rills manifests as high water in the Gyöngyös River that flows through and inundates parts of Kőszeg, producing levels of accrued debris and sediment veneer that also pose threats to local water bodies. Rehabilitating the health and resilience of natural and constructed water systems was therefore prioritized by an interdisciplinary team.

Kőszeg has neither its own drinking water nor a wastewater treatment plant. Water supply comes from the nearby Perenye water base, near Szombathely, while combined stormwater and sewage are treated at a Szombathely-based plant. These "hard-path", EU-regulated legacy systems were therefore excluded from consideration under the study initiative. Instead, the engineers had to collaborate with ecologists and planners in the use of "soft path" or green infrastructure engineering as solutions to water quality and water balance. One recommendation involved a constructed wetland (8,000 cm) placed in a low area adjacent to the Gyöngyös, comprised of a holding pond for stormwater retention, infiltration basins,

wetland cells for pollutant mitigation via biofiltration, and meandering streams. In the restoration of a degraded canal paralleling the Gyöngyös, the team sought engineering expertise for the integration of micro-hydroelectric turbines to capture energy of the restored stream's flow. Finally, inter-disciplinary, soft-path solutions to area flooding relied on improved forestry practices, revegetation of the upland, and imposition of naturalized check-dams [11].

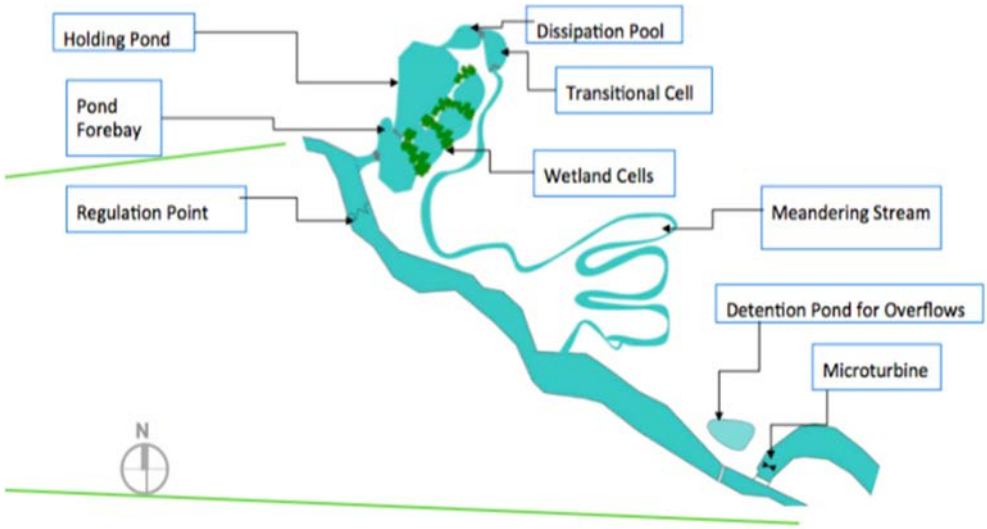


Figure 2: Proposed wetland near the Gyöngyös.

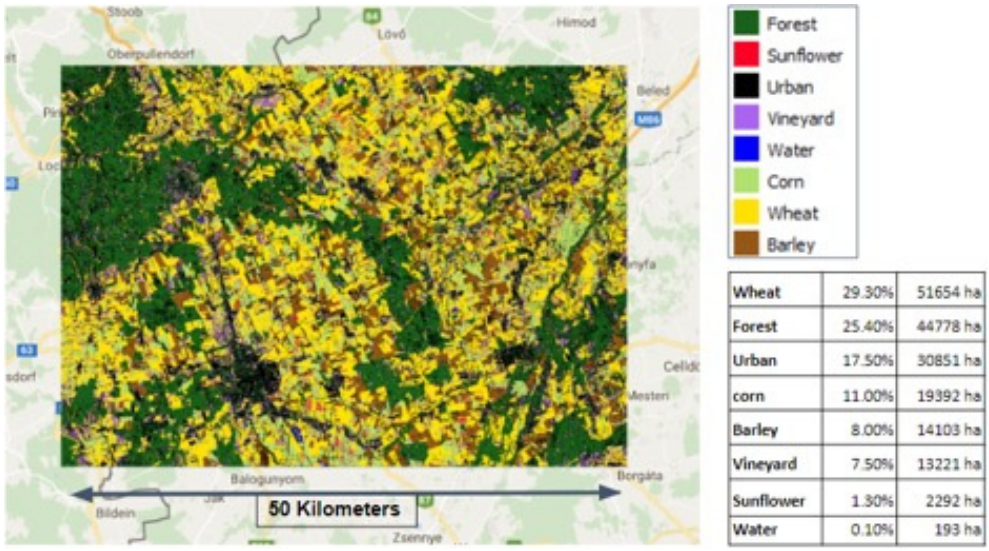
5.2 Enhancing the forestry and the agricultural sectors

The Kőszeg region's mixture of large forested and agricultural lands that supply local fibre, fuel, and food stuffs are under threats from climate and land cover changes as well as sub-optimal market and ownership conditions. More resilient models were envisioned by interdisciplinary teams for both forest and field production based on more closed-loop, sustainable and equitable food and fiber management practices.

Expansion of the European *Pro Silva* forest management principles initially being piloted in the Kőszeg Mountain region will further reduce erosion from sub-optimal logging practices. *Pro Silva* embraces selective cutting techniques, management of soil nutrient cycles, and replanting of more diverse and climate-adapted species to regenerate current forest losses. The teams recognized that such improved public and private area forest management will not only reduce flooding but strengthen the tourism-based economy in upland recreational areas that feature nature trails, biking and hiking.

Agriculture, today mostly privately owned, covers approximately 60% of the Kőszeg region. Long growing seasons, flat terrain, and high nutrient soils have made this area highly suitable for agricultural enterprise. An assessment of the area was undertaken using statistical crop and economic data, along with high resolution Sentinel-1 monthly-averaged radar images for the period of June 2017–May 2018. This allowed the team to classify and quantify lands in production: crop output and potential crop waste from the area's wheat, barley and corn, with sunflower, and sugar beets (Fig. 3). Cross-disciplinary recommendations included

diversifying agricultural output locally, with more reliance on agro-forestry and inter-cropping techniques to increase crop resiliency, improve public nutrition, and promote gastro-tourism, including the revival of Kőszeg's historic closed gardens (private holdings for diverse domestic food production).



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 3: Categorization of agricultural areas and their outputs by modelling.

Following the privatization and shifts in compensation practices during the 1990s, the efficiency and profitability of Hungarian agricultural production decreased [12]. To revitalize agricultural enterprise locally, participants with agronomy, ecology, and economics backgrounds proposed an alternative to the national agricultural model governing the region, one largely controlled by enterprises that vertically integrate the production/marketing system. Based on the collaborative operations model utilized by Kőszeg's vineyards, the team proposed a more cooperative, shared agricultural model run as a non-profit entity. This would increase profits to smaller and medium-sized farm enterprises, enhance local food variety, and create new jobs. It would complement the resurgent boutique dairy, cheese-making, viticulture and pig-farming operations underway locally, and would amplify both local and cross-border food sales and promote gastro-tourism, again factors for economic growth.

5.3 Transitioning to a low-carbon economy

Although potentially well-endowed with renewable energy sources, the nation in general, and Kőszeg in particular, depend upon electricity generated from both fossil fuel and nuclear power plants, leaving Hungary the least renewables-dependent country in the EU. As throughout much of Hungary, winter heating in Kőszeg relies on a combination of imported fossil fuel and in-home stove burning of wood combined with household waste, a problematic practice negatively impacting air quality and human health [13].

A diversified solution to Kőszeg's wintertime pollution promotes improvement of wood-curing practices, upgrades to domestic stoves, improved enforcement of trash-burning

prohibitions, along with energy performance upgrades to historic building envelopes and investment in domestic rooftop solar thermal panels, enhancing the town's renewable energy mix while lowering adverse emissions.

A similar cross disciplinary response, supports energy from waste, the recovery of biomethane from both the local landfill and waste slurry from a nearby pig farm. The farm's annual manure output of 24,000 liquid m^3 will, when recovered and anaerobically digested (biogas separated from biosolids in the absence of oxygen), yield 35,895 m^3 of methane. Valorization of this otherwise wasted gas, together with recovery of the currently flared 26,280 m^3 of methane sourced at the municipal waste-handling facility, could renewably generate 77 and 56 MWh of electricity respectively.

The entire team contributed ideas for recovery and valorization of multiple area wastes as the organizing idea for a new enterprise. The Eco-Innovation Center (EI Center), housed in a nearby underutilized factory complex was envisioned as a showcase of the closed-loop economy (see Section 5.4). Additional anaerobic biodigestion housed at the Center would process the town's food, crop waste and forestry residuals for the facility's heat and power. Biodigested waste from the proposed micro-brewery (2,000 beer barrel annual production capacity annually) would yield 2,500 tons of spent grain that could produce an estimated 194,000 m^3 of biogas annually, equivalent to 414.5 MWh of electricity. The biogas would support cooking at the EI Center's gastronomic facilities (bakery and restaurant) with the residual slurry applied as agricultural fertilizer. Finally, the application of these closed-loop and renewable energy technologies, combined with installations of solar panels and solar thermal at the EI Center would help to de-mystify low-carbon technologies and encourage further public support of waste valorization and deployment of renewables.

5.4 Interconnecting Koszeg's assets for economic development: The EI Center

Thanks to its geography and unique history, Kőszeg sustains multiple cultural, historic, natural, and physical resources. Much of its building stock stems from the 16th and 17th centuries, while its castle and remaining portions of its encircling town wall date from medieval times. Tourism (90% from within Hungary, 10% from Austria) constitutes a critical part of Kőszeg's economy, and effects day-to-day town life [14]. However, tourism remains hampered by lack of diversity in accommodation and commercial enterprises, at the same time the town has seen substantive increases in historic building vacancy. Team interests in planning, economics, engineering and historic preservation converged in the proposal for the adaptive reuse of the numerous vacant or under-utilized historic structures to diversify tourist accommodations and house new commercial activities, creating new employment opportunities.

The entire team focused on forging a demonstration of closed-loop cycling of resources and wastes recovered from the water, forestry, agriculture, energy sectors. This required close examination of the diverse inputs and outputs of Kőszeg's existing and proposed commercial and industrial enterprises. Identifying potential reciprocities across these collective systems, then designing correlating exchanges to utilize waste flows, resulted in a vision for specific, regenerative economic opportunities at the aforementioned EI Center. This new enterprise would be housed in an under-utilized early 20th century factory on Kőszeg's outskirts (Fig. 4).

The EI Center would optimize symbiotic waste exchanges from across all the study sectors (Fig. 5). It would manufacture sustainable building products fabricated from local biological and technical waste streams for use in local historic building adaptive reuse. It would incubate

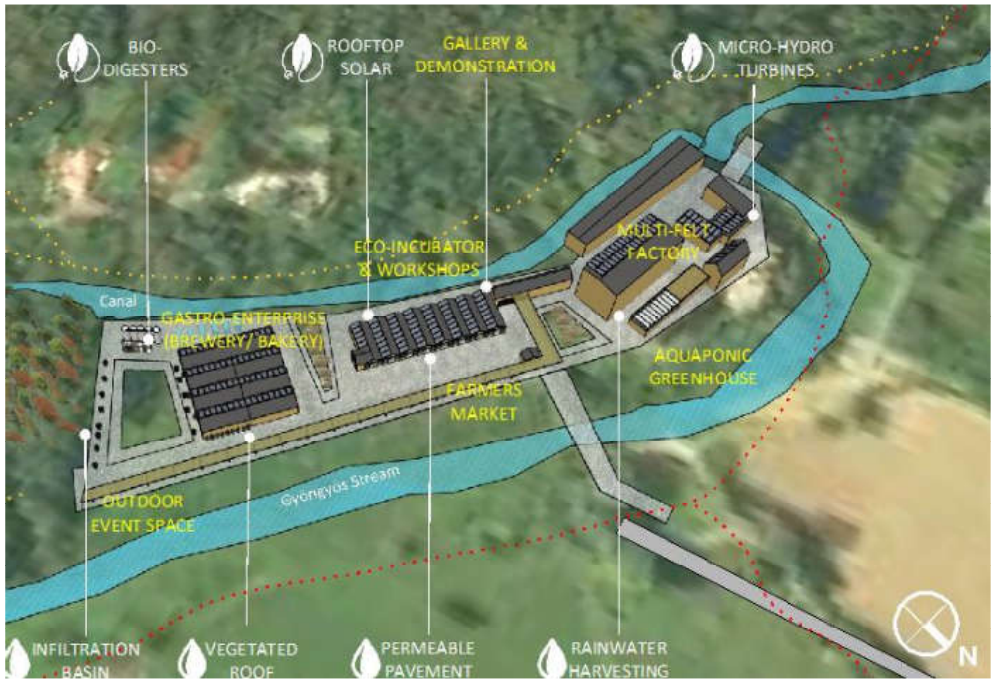


Figure 4: Site plan of the EI Center.

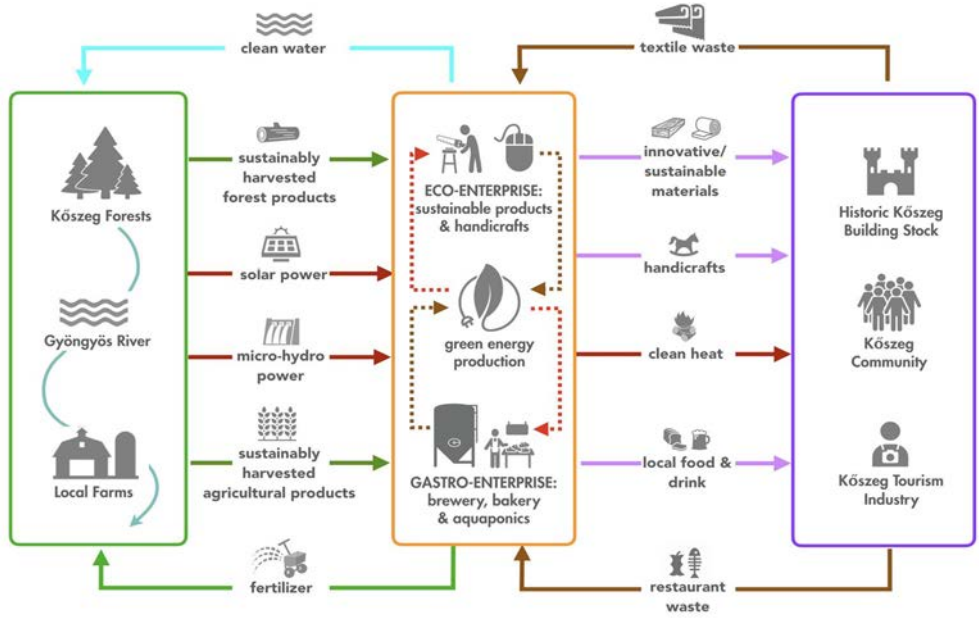


Figure 5: Circular (closed-loop) relationships.

production and sales of local food products, sustainably grown in Kőszeg's farms, orchards, dairies, and vineyards. The EI Center was planned to house a microbrewery, a bakery utilizing spent brewery waste and locally sourced grains in its beer and baked goods, and an on-site greenhouse taking advantage of CO_2 and waste heat recovered from these activities. Space on site is reserved for labs and collaborative shop space for business skill training. The EI Center would house workshops, open lab space, galleries, and provide tours for visitors.

In summary, the EI Center would as a venue where local products are showcased and a visiting public can experience the workings of a circular economy. It could demonstrate "loop-closing" and regenerative/ restorative design at many scales, from the food-waste-to-energy loop on site, to agro-forestry products, to wood-curing and storage for clean energy, to the upcycling of agro and textile waste from the Kőszeg region into sustainable building products.

6 SUMMARY: THE CIRCULAR ECONOMY AS ONE ROADMAP TO RURAL RENEWAL AND RESILIENCY

Today, the forces of urbanization and market globalization threaten to further undermine the socio-economic, environmental and cultural stability of rural settlements. Climate change portends greater disruptions still, with potential disturbances that are interdependent, dynamic, and complex. To build resiliency against these destabilizing forces, we need to demonstrate more holistic and synergistic approaches to rural revitalization.

Illustrated here, this project undertook an interdisciplinary inventory of the settlement's natural, constructed and economic resources. It then sought to identify potential elements of the town and bioregion's asset pool that could be better integrated and optimized. By examining the potential advantages of natural systems regeneration, renewable energy infrastructure, and local waste recovery and valorization, the Kőszeg study attempted to objectify and makes more tangible the abstract principles of the circular economy.

The project underscored the value of an integrated approach to complex problem-solving using participants mostly trained to think and work inside disciplinary silos. It was a testing ground for inter-professional collaboration. Notwithstanding initial insecurities, the team worked well in concert to develop the project solutions taking advantage of cross-sector synergies, enjoying a shared accountability for the outcome. Overall they recognized the benefits of teamwork in achieving integrated solutions.

A demonstration circular economy, such as that modelled for Kőszeg, potentially exemplifies a new pathway for securing future rural renewal of other towns and regions drained by outmigration and undermined by natural resource decline. In terms of its systems thinking and ecologically-reflexive planning process, the case study has sufficient generality to be more widely applied.

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