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BIOENERGY CROPS AS NEW COMPONENTS OF RURAL AND AGRICULTURAL LANDSCAPES: ENVIRONMENTAL AND SOCIAL IMPACT, BIODIVERSITY, CULTURAL HERITAGE AND ECONOMY

Bioenergia termények, mint a vidéki és mezőgazdasági kultúrtájak új komponensei: környezeti és társadalmi hatás, biodiverzitás, kulturális örökség és gazdaságosság

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Abstract

Large scale cultivation of bioenergy crops can substantially alter the appearance and the ecology of rural and agricultural landscapes, which constitute a valuable asset of our cultural heritage. The ecosystems and the built heritage of agricultural landscapes require holistic management structures built on self-sustaining ecological cycles and the sustainable use of ecosystem services put into the context of economical and demographical conditions of local and regional development strategies. Furthermore, the natural and cultural heritage of rural landscapes can play an important role for boosting economic growth and social cohesion if protected and used with a long term sustainability approach. This is particularly important for those rural landscapes, where establishing large scale traditional monoculture of bio energy crops might threaten both previously well functioning agro-ecosystems and the cultural values of the agricultural landscapes. However, sensible cultivation of energy crops, particularly energy forests, in degraded, polluted areas or on territories of low soil quality may be beneficial and serve as means for ecological reconstruction and creation of new habitats. We propose to apply renewable energy based, landscape centered, sustainable micro-regional development strategies in rural areas, where ecologically acceptable level of bioenergy feedstock production supports not only organic agriculture including grey water irrigation and control of invasive species, but even the protection, reconstruction and sensible use of the built and intangible cultural heritage of the cultural landscape.

Key words: *bioenergy crops, agricultural landscapes, cultural heritage, biomass, agroforestry-systems*

Jel Code: N5; N50

Összefoglalás

A bioenergia termények nagybani művelése jelentősen megváltoztathatja a kulturális örökségünk értékes elemeit képező vidéki és mezőgazdasági tájak kinézetét és ökológiai viszonyait. A mezőgazdasági tájak ökoszisztémái és épített öröksége az önfenntartó ökociklusokra épülő, komplex menedzsment struktúrákat igényel, melyek egyaránt figyelembe veszik az ökoszisztéma szolgáltatások fenntartható hasznosítását továbbá a helyi és regionális fejlesztési stratégiák gazdasági és demográfiai *feltételeit. A vidéki tájak természeti adottságai és kulturális öröksége jelentős szerepet játszhatnak a vidék gazdasági fellendítésében és a szociális kohézió erősítésében abban az esetben, ha biztosítjuk védelmüket és használatukat egy hosszú távú fenntarthatósági koncepció alkalmazásával. Ez különösen fontos lehet azokon a tájakon, ahol a bioenergia termények nagybani termesztése fenyegető lehet mind a korábban jól működő agro-ökoszisztémákra mind a mezőgazdasági tájak kulturális értékeire. Mindezek ellenére, a bioenergia terményeknek, különösen az energiaerdőknek a céltudatos telepítése csökkent értékű, szennyezett területeken vagy alacsony minőségű talajokon kifejezetten hasznos lehet, mint a fitoremediáció és új élőhelyek létrehozásának eszköze. Javasoljuk a megújuló energiákra épülő, kultúrtáj központú, fenntartható mikroregionális fejlesztési stratégiák alkalmazását a vidéki területeken, ahol a bioenergia alapanyagok termelése nem csupán a biológiailag tisztított szennyvizes öntözést is alkalmazó biogazdálkodást és az invazív fajok ellenőrzését teszi lehetővé, de biztosítja az adott kultúrtáj épített és eszmei örökségének védelmét, rekonstrukcióját és ésszerű használatát is.*

Kulcsszavak: *bioenergia termények, mezőgazdasági kultúrtájak, kulturális örökség, biomassza, agrár-erdészeti rendszerek*

Introduction

Conservation of cultural landscapes and production of bioenergy feedstocks

The cultural heritage of rural landscapes regarding the wide meaning of tangible and intangible heritage represents a great opportunity for growth, innovation and participative development (bottom-up approach) for local communities. We refer in particular to the relationship between the populations and their territories, which are being shaped since centuries and whose interrelation is a precious source of cultural traditions, built heritage, artefacts, typical products, traditional skills, beliefs, legends etc. worth to be preserved and used in the appropriate context of development strategies. Rural territories express this great cultural heritage as result of the "mutual shaping" between populations and their landscape (i.e. ancient meadows, wetlands, seaside, salt works, shallow lakes, agricultural landscapes, ancient orchards and viticultural areas, national parks, etc.). Cultural landscapes are sites associated with a significant event, activity, person or group of people; they can be grand estates, farmlands, public gardens and parks, college campuses, cemeteries, scenic highways, and industrial sites or works of art, narratives of cultures, and expressions of regional identity. Cultural landscapes can range from thousands of hectares of rural tracts of land to a small homestead with a front yard of less than one hectare. Like historic buildings and districts, they reveal aspects of a country's origins and development through their form, features, and the ways they were used. Cultural landscapes also reveal much about our evolving relationship with the natural world. Large scale monoculture farming threatens both previously well functioning agro-ecosystems and the cultural values of the aforementioned rural and agricultural landscapes. For short-term efficiency, crops for both food and agro-fuels are cultivated in monocultures and constitute a number of social and environmental problems by implying a high use of inputs such as toxic agrochemicals and machinery. Furthermore, the takeover of land by monocultures also causes rural depopulation, destroying local community life and local economies. While certain perennial biofuel feedstocks and bioenergy forests can improve soil quality and biodiversity, reduce greenhouse gas emissions and enhance water quality, some large-scale industrial models of modern biofuel production can negatively impact ecosystem services through the excessive use of synthetic fertilizers and agrochemicals, grassland conversion and deforestation [Gao et al. 2011; Raghu et al. 2011; Pacheco et al. 2012]. Particularly serious concerns were raised concerning food security, especially in regions with widespread poverty, political uncertainty, and fragile agricultural systems, which are likely to be exacerbated with accelerating climate change [Brown and Funk 2008]. However, the right choice of bioenergy crops, the territory of cultivation and cultivation methods might counteract the harmful environmental and social effects of monoculture, particularly if connected to bio-remediation and soil improvement programmes often creating new employment opportunities. A number of studies have demonstrated, that there is considerable potential for increasing economically and ecologically viable bioenergy production even further, to meet a substantial fraction of future energy needs without compromising any aspect of sustainability [Smeets and Faaij 2007; Somerville et al. 2010]. Thus, bioenergy development may offer developing countries many advantages, ranging from energy security to poverty reduction, infrastructure development and economic growth [Cushion et al. 2010; FAO 2010a].

Bioenergy feedstocks from agriculture and forestry

A wide range of materials have been proposed for bioenergy feedstocks, including grain, crop residue, oilseed rape, cellulosic crops (e.g. switchgrass, sugarcane) and various tree plantations (salix, poplar, eucalyptus, pine, acacia, etc.), which are largely used for paper pulp, charcoal, timber and, increasingly for biomass with the possibility that they will be used for agro-fuels in future [Cerri et al. 2004; Edmonds 2004; Paustian et al. 2004; Sheehan et al. 2004; Dias de Oliveira et al. 2005; Eidman 2005]. These products can be burned directly, but often are processed further to generate liquid fuels such as ethanol or diesel fuel [Richter, 2004]. Although these fuels release CO_2 when burned, this CO_2 is of recent atmospheric origin (via photosynthesis) and displaces CO_2 which otherwise would have come from fossil carbon sources and, therefore, do not increase the CO_2 content of the atmosphere. The net benefit to atmospheric CO_2, however, depends on energy used in growing and processing the bioenergy feedstock [Spatari et al. 2005]. Agroforestry is the production of livestock or food crops on land that also grows trees, either for timber, firewood or other tree products. It includes shelter belts and riparian zones/buffer strips with woody species. The standing stock of carbon above ground is usually higher than the equivalent land use without trees, and planting trees may also increase the soil carbon sequestration [Guo & Gifford 2002; Paul et al. 2003; Oelbermann et al. 2004; Mutuo et al. 2005], though the effects on N_2O and CH_4 emissions are not particularly well known [Albrecht & Kandji 2003].

Biomass supplies an increasing share of electricity and heat and continues to provide the majority of heating produced with renewable sources. An estimated 62 GW of biomass power capacity was in operation by the end of 2010. Biomass heat markets are expanding steadily, particularly in Europe but also in the United States, China, India, and elsewhere. Trends include increasing consumption of solid biomass pellets (for heat and power) and use of biomass in combined heat and power (CHP) plants and in centralized district heating systems. China leads the world in the number of household biogas plants, and gasifiers are used increasingly for heat applications in small and large enterprises in India and elsewhere. Biomethane (purified biogas) is increasingly injected into pipelines (particularly in Europe) to replace natural gas in power and CHP plants. The establishment of bioenergy production capability can have significant positive economic and energy implications. Some projections indicate that up to 30 percent of liquid fuel demand could be supplied by biomass. This biomass requirement will need to be supplied from crop residues and a new generation of dedicated bioenergy crops — which are sustainable and integrated with existing food, feed and fiber cropping systems — that are designed for production of biofuels. The most important biomass feedstocks are the following:

- Animal wastes/animal manure, mainly for biogas
- Crop residues for both combustion and biogas
- Forest products and by-products of forestry related industry for combustion
- Dedicated woody bio energy crops (trees, such as willow, birch, poplar, acacia, etc.)
- Grain for bioethanol
- High-tonnage sorghums for bioethanol
- Microalgae for both biodiesel and bioethanol
- Municipal solid waste/urban waste
  - for combustion
  - compostable
  - suitable for co-fermentation with waste water sludge
- Waste water sludge (fermentable) for biogas
- Oilseed crops for biodiesel
- Sugar cane/energy cane for bioethanol
- Sweet sorghum for bioethanol
- Switch grass, suitable both for bioethanol production and combustion
- Industrial hemp for combustion

Regardless of the actual potential, biomass resources must be produced, harvested/collected, transported, stored, and processed based on new paradigms associated with input costs, production schedules, capacities and capabilities. The challenge for researchers, producers, equipment manufacturers, and end users will be to incorporate production systems that are sustainable and efficient, using existing systems when appropriate. In addition, improvements in the conversion — biochemical, physico-chemical, and thermo-chemical — of ligno-cellulosic biomass to biofuels must rapidly progress within the next five to seven years to meet biofuel production goals. A critical element in the ultimate success of biofuel production will be the linkage between biomass feedstock development, production, harvesting, transporting, storing, and processing into biofuels/bioproducts and/or energy. The core questions in connection with bio energy production comprise ecological, technological, economical and even social factors as follows:

- What is the realistic, feasible, economically affordable level of production?
- What are the leading viable feedstocks in different geographical areas?
- What conversion technologies might persist or emerge?
- How will biomass production affect the food vs. fuel issue?
- What are the impacts on water usage and soil erosion?
- What are the carbon impacts?
- What are the impacts on animal agriculture?
- How can bioenergy crops be produced in a *sustainable* manner?
- Is there available land?
- How far can bulky biomass be affordably hauled?

The interactions of an expanding bioenergy sector with other land uses, and impacts on agro-ecosystem services such as food production, biodiversity, soil and nature conservation, sustainable management of cultural landscapes and carbon sequestration have to be studied in each geographical area [Smeets et al. 2007)]. Major transitions are required to exploit the large potential for bioenergy. Improving agricultural efficiency in developing countries is a key factor. Latin America, sub-Saharan Africa and Eastern Europe are promising regions for bioenergy, with additional long-term contributions from Oceania and East and NE Asia.

Liquid biofuels, bioethanol and biodiesel provided about 2.7% of global road transport fuels in 2010. The global ethanol industry recovered in response to rising oil prices, with production increasing 17% in 2010, and some previously bankrupt firms returned to the market. The United States and Brazil accounted for 88% of global ethanol production; after several years as a net importer, the United States overtook Brazil to become the world's leading ethanol exporter. The EU remained the centre of biodiesel production, but due to increased competition with relatively cheap imports, growth in the region continued to slow. Bioethanol is available in several EU countries, where the best networks have been developed in Sweden and Germany, but only as a complement to the products of major actors of fossil fuel supply chains. The diversity of players in the advanced biofuel industry continued to increase with the participation of young, rapidly growing firms, major aviation companies, and traditional oil companies.

Ethanol, a renewable alternative to petroleum-based transportation fuels, is a type of alcohol produced by fermenting and distilling simple sugars from a wide range of biological sources. While ethanol can be made from sugarcane, sugar beets, wheat, barley, potatoes, and many other crops, over 90 percent of U.S.-produced ethanol is currently made from corn. Newer manufacturing processes allow ethanol to be made from cellulosic feedstocks, such as agricultural waste, forest residue and municipal solid waste. While not yet widely commercialized, these processes are currently the subject of intensive scientific research and development. As cellulose-based ethanol becomes a reality, new markets will emerge for crop residues as well as energy crops like switchgrass. Switchgrass is a native warm-season, perennial grass indigenous to the Central and North American tall-grass prairie into Canada. The plant is an immense biomass producer, provides high-quality forage for cattle and also offers food and shelter for wildlife. Switchgrass, with its sod-forming roots, prevents erosion. It can reach heights of 3m or more. Its high cellulosic content makes switchgrass a candidate for ethanol production as well as a combustion fuel source for power production. However, ecological considerations are also discussed, primarily due to the invasive character of switchgrass in areas, where this plant is not indigenous and it can replace other desirable species. Many challenges will also emerge for truly sustainable ethanol production, including protecting soil and water quality and preserving opportunities for local ownership.

Biodiesel is a versatile, clean-burning fuel made from renewable, biodegradable sources. It can be blended with petroleum diesel in any proportion and used in diesel engines without major modification. Biodiesel is essentially permanently thinned plant or animal-based oil, with a viscosity approximating that of standard diesel fuel. Biodiesel can be made from almost any vegetable oil or animal fat, through a process that is neither difficult nor prohibitively expensive. A *cetane number* is an indicator of diesel fuel quality, measuring the readiness of fuel to ignite when injected into the engine. Biodiesel's cetane number is higher than that of standard diesel fuel, and this advantage may partly compensate for its lower energy content. Because biodiesel ignites more readily in diesel engines than petrodiesel, some authorities recommend setting the injection timing back by two to three degrees from top-dead centre. This will sometimes cause the engine to run quieter, although it may also slightly reduce the power [Pelly, 2003]. Using biodiesel instead of petroleum diesel reduces emissions of most air pollutants and greenhouse gases. Biodiesel is biodegradable and essentially non-toxic. Biodiesel production is growing rapidly, and some farmers are already producing their own fuel, but narrow minded taxation rules in certain countries (e.g. in Hungary) can make this less economical if not impossible.

Biogas is one of the most important biofuels, can be made from fermentation of organic municipal waste, animal manure, plant residues, bioenergy crops produced for biogas, and wastewater sludge. Biogas comprises primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes (organosilicon compounds). Biogas can be used as a fuel in any country for any heating purpose, typically used in a gas engine to convert the energy in the gas into electricity and heat. Biogas can be compressed, much like natural gas and, after cleaning, used to power motor vehicles. In the UK, for example, biogas is estimated to have the potential to replace around 17% of vehicle fuel [Baldwin, 2008]. Biogas is a renewable fuel, so it qualifies for renewable energy subsidies in some parts of the world. Biogas can also be cleaned by removal of H_2S, CO_2 and siloxanes and hereby upgraded to natural gas standards when it becomes pure biomethane. Engine maintenance costs may rise steeply if silane contamination is not adequately controlled. Fuel cells are also very sensitive to the effects of silanes and may be rendered useless by quite small concentrations in the fuel. China is the world-leader in the number of household biogas plants, and gasifiers are used increasingly for heat applications in small and large enterprises in India (gobar gas) and elsewhere. Biomethane (purified biogas) is increasingly injected into pipelines (particularly in Europe) to replace natural gas in power and CHP plants [REN21, 2011].

Short Rotation Forestry (SRF) as a new way of biomass production and conservation of forests and agricultural landscapes

Shortage of natural wood is a common problem in different countries – particularly for forest industries in developed countries and for fuel in developing countries. The agricultural expansion of the last decades resulted in deforestation and forest degradation and the illusion of economic development, seemingly benefiting billions of people in a short term and causing severe environmental and social problems for future generations. The rapid expansion of agriculture for food, fuel and other products has resulted in significant greenhouse gas (GHG) emissions. An estimated 4 - 14 per cent of global GHG emissions are associated with deforestation and degradation, making agriculture a major component of the human factors of global climate change mitigation efforts [Fig. 1; Vermeulen et al. 2012, Rautner et.al. 2013]. It is therefore critical that we fully understand the relationship between the development of the agriculture sector and its impact on forests and propose appropriate integrated solutions. Greater attention to short-rotation forestry on agricultural land and on fertile forest soils could offer a way to provide forest industries with enough wood resources and people in the developing world with enough fuel, while conserving natural forests [Christersson, 2005]. Short-rotation forestry (SRF) is a fast expanding silvicultural practice where high-density, sustainable plantations of fast-growing tree species, which produce woody biomass on agricultural land or on fertile but degraded forest soils. Trees are grown either as single stems or, more often, as coppice systems (SRC = Short Rotation Coppice), with a rotation period of less than 30 years and with an annual woody production of at least 10 tonnes of dry matter or 25 m^3 per hectare. Due to economic and ecological difficulties in creating optimal water and nutrient conditions, competition from herbaceous plants and other tree species and biotic and abiotic damage the entire growth (i.e. biomass producing) potential of conventional forestry is not sufficiently utilized.

Short rotation forestry, excluding most of these limiting factors, might environmentally and economically optimize the use of natural resources provided that environmental and practical aspects are taken into consideration in the assigned areas of production [Landsberg et al., 1997]. The biomass produced is used for construction, pulp and paper, fodder and energy, replacing wood from tropical forests and from protected forest areas and thus help conserve valuable natural forests and valuable cultural landscapes. Examples for sustainable short rotation forestry include hybrid poplar plantations (*Populus trichocarpa* and *Populus deltoides*) with outstanding growth potential in the United States, Canada and India, willows (e.g. *Salix phylicifolia*) in Sweden, bamboo in China and Ethiopia, irrigated forests of *Eucalyptus sp*. in Australia and Brazil with annual production of up to 40 tonnes of dry matter per hectare [Wildy et al., 2000; Baker, Duncan and Stackpole, 2005], plantations of hybrid aspen (Populus tremula × Populus tremuloides) in Finland and many other woody species around the world. SRC plantations have also substantial values as elements of agricultural landscapes as special habitats for birds and game.

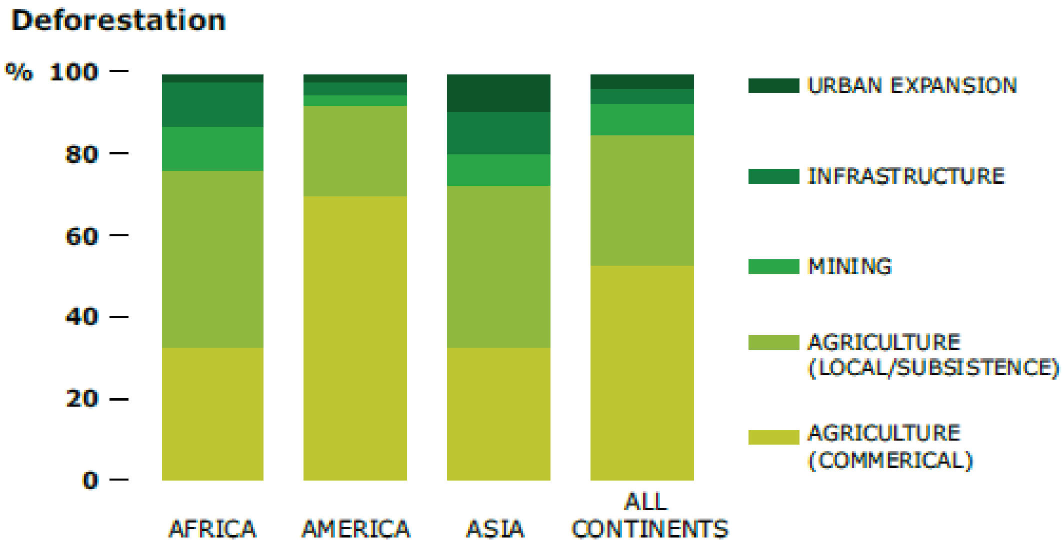

Figure 1: Main factors of deforestation and forest degradation 2000-2011 in tropical and sub-tropical countries [Rautner et al. 2013]

Figure 2. Harvesting bioenergy willow (Salix sp.) in Hedemora, Sweden (Photo: Sándor Némethy)

According to quite recent field experiments, species abundance in SRC (short rotation coppice) plantations can be more heterogeneous than in arable lands and therefore, SRC plantations form novel habitats leading to different plant species composition compared to conventional land uses. Their landscape-scale value for phytodiversity changes depending on harvest cycles and over time. As a structural landscape element, SRC plantations contribute positively to phytodiversity in rural areas, especially in land use mosaics where these plantations are admixed to other land uses with dissimilar plant species composition such as arable land, coniferous forest and also mixed forests [Baum et.al. 2012]. Short rotation forests are excellent objects for natural waste water cleaning. Agricultural deployment of wastewater for irrigation is based on the value of its constituents, which are used as fertilizers. Crop irrigation with insufficiently treated wastewater may result in health risks. Use of untreated sewage effluent for irrigation exposes the public to the dangers of infection with a variety of pathogens such as protozoa, bacteria and viruses. Thus the benefit of wastewater reuse is limited by its potential health hazards associated with the transmission of pathogenic organisms from the irrigated soil to crops, to grazing animals and humans [Gupta et al., 2009]. Human health risks from wastewater irrigation include farmers' and consumers' exposure to pathogens and organic and inorganic trace elements. Protective measures such as wearing boots and gloves, and changing irrigation methods can reduce farmer exposure [Qadir et al., 2010]. Waste water should satisfy some quality indicators as chemical structure, availability of gases, content of organic substances and bacteria, muddiness, temperature, etc. Those indicators depend on salt tolerance of the cultivated crops, chemical structure and water permeability of the soil, drainage of the ground, characteristics of the rainfalls, background content of heavy metals, meteorological and hydro-geological circumstances, irrigation technology, applied agricultural techniques, etc.

The suitability of the treated water for irrigation can be determined on the basis of results from chemical analyses, vegetation and field experiments, as well as comparing various crops irrigated with clean and treated wastewater during a longer period of time [Panoras et al. (1998, 1999, 2000, 2001]. Thus, biologically cleaned waste water is a substantial resource. Utilization of short-rotation forests as vegetation filters for waste products is strongly supported in Sweden [Perttu and Obarska-Pempkowiak, 1998; Dimitriou and Aronsson, 2004. After biological cleaning, a simple sand filter system or other particle filters can remove particles – if needed – and low concentration of disinfectants will assure the appropriate water quality. This water should be almost entirely free of bacteria and can be used for irrigation. In agriculture it is possible to establish combined production structures, which include the use of bio-energy crops and forests as biological filters (root filtration), the application of biologically cleaned waste water, free from heavy metals, as crop nutrient through irrigation and the co-fermentation of waste water sludge and organic waste for production of bio-gas. For the safety of public health and the protection of groundwater and surface watercourses and natural habitats the environmental legislation in all developed countries require the thorough control and environmental consequence analysis as well as the systematic monitoring of the re-use of partially cleaned waste water (the "grey water"). Furthermore, the potential for bio-remediation should be taken into consideration, since waste products can also contain polluting heavy metals, which some willow clones are able to absorb efficiently. When wood from this type of plantation is burned, heavy metals can be extracted from the fly ash and bottom ash. However, this process is not yet economical, so today most of the ashes are deposited at safe city waste disposal sites.

In a holistic integrated food and energy system there is no conflict between bio energy production and food supply, the ecological footprint is sufficiently small. A transition is needed from fossil fuel centred, ineffective and inefficient societies to the ecologically and economically viable, recycling society. Technological developments (in conversion, as well as long-distance biomass supply chains such as those involving intercontinental transport of biomass-derived energy carriers) can dramatically improve competitiveness and efficiency of bioenergy [Hamelinck et al. 2004; Faaij 2006].

The landscape approach in rural planning: a holistic management concept integrating the cultivation of bi energy crops

In order to balance the competing land use goals of agriculture and forestry, it is important to understand the dynamics which drive land-use change across the landscape. A landscape approach also permits alignment with local or district planning processes, enables cross-departmental or ministerial dialogue and facilitates the negotiation of priorities and trade-offs. Therefore, a complex management system is required, taking into account the environmental, social and economic aspects of bioenergy feedstock production on agricultural land including the value of rural heritage of these environments (Fig. 3).

Short rotation coppice (SRC) has considerable potential for biomass production for the benefit of growers, developers, consumers, local communities and the environment. However, as it is a new element within the landscape, it is therefore important to assess the potential impact of proposed changes in connection with the introduction of these fast growing species to rural and agricultural landscapes, which evolved over many centuries and are highly valued for their variety and local distinctiveness. From the landscape conservation viewpoint, the fast growing nature of SRC crops is very important: after cutting, the stem base or coppice stool quickly produces new coppice shoots. The expected productive life of an SRC crop is up to 25 years. At the end of the period sites can be used again for arable or grassland production resulting in alternating landscapes due to rapidly occurring visual changes [Bell and McIntosh, 2001]. However, SRC has some characteristics of woodland:

- it grows tall enough to create a 3–dimensional mass in the landscape and, unlike most conventional field crops, and may impede views;
- the rate of change in a landscape, particularly associated with harvesting, can be rapid;
- its colour and texture are more like trees than field crops and it reflects seasonal changes in the same way as woodland;
- all age classes can be represented by phasing planting and harvesting.

Depending on the current character and sensitivity of the landscape, SRC might not cause visual problems in some landscapes but in others care will be needed both in the siting of the crops and in the way in which they are managed. The first consideration must be the suitability of the proposed location. According to previous experiences, lowland landscapes with high levels of tree and woodland cover and arable or mixed farming are most suitable for SRC. In case of large scale planting the characteristics of the landscape (enclosure, openness and landform type) must be taken into account in the design of the schemes. The cropping of bio energy forests is heavily mechanised and requires land suitable for mechanical operations: this excludes steep or boggy ground, but in certain, fairly firm waterlogged areas is still possible (e.g. willow plantations in Sweden, Fig. 2).

It is important to build diversity into large scale planting by varying age structure and introducing open space, so that the crop is subdivided at a scale that suits the particular landscape type. Some landscapes, with particularly valuable cultural heritage, such as parkland and historic designed landscapes may be unsuitable for the introduction of coppice systems as these can destroy the structure and the character of these precious cultural assets [Bell and McIntosh, 2001; Baum et.al. 2012].

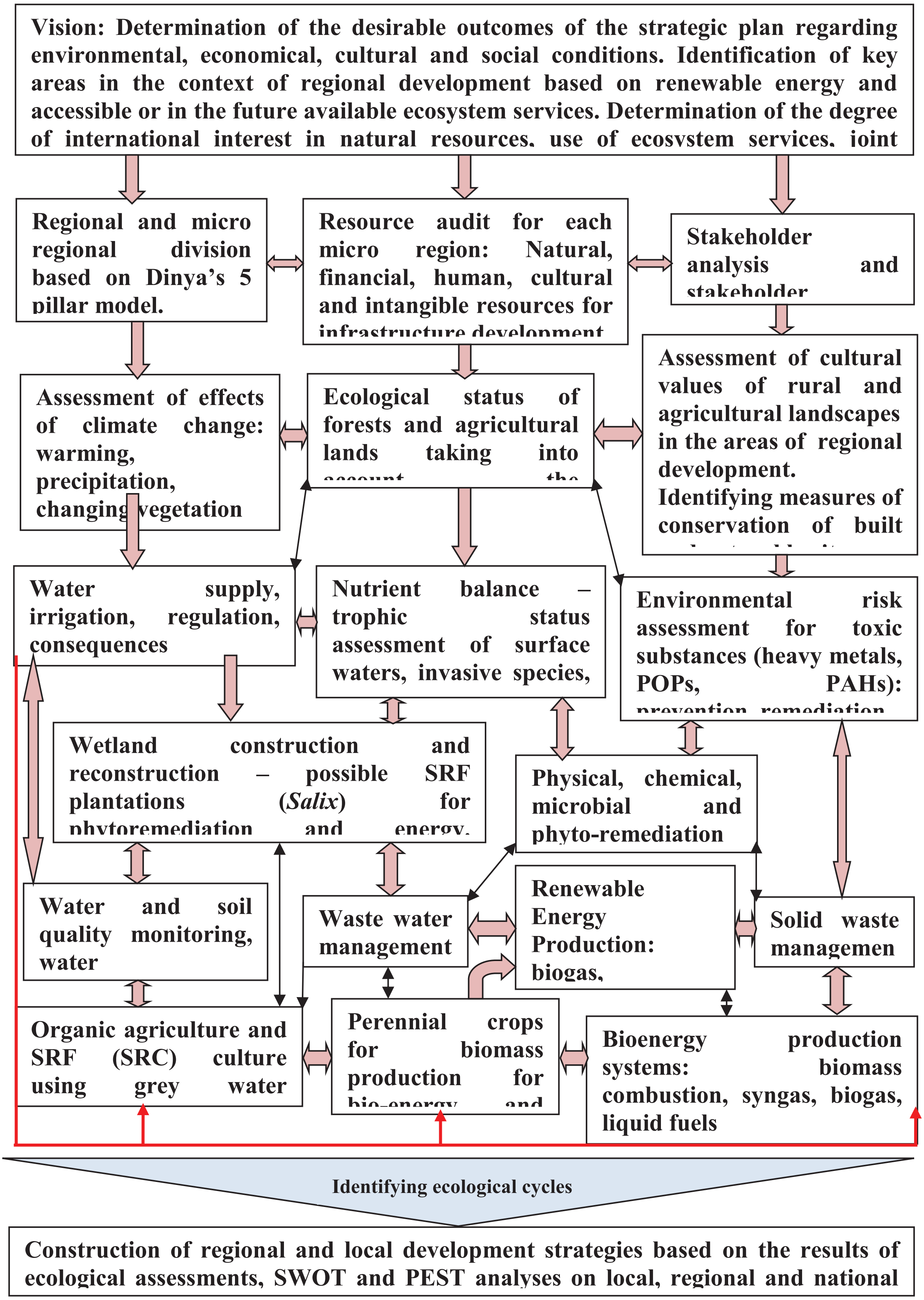

Fig. 3. Rural management strategy implementation flow chart (modified after Némethy & Molnár, 2014).

Conclusions

Bioenergy is one of the most sustainable forms of renewable energy. Agriculture and agriculture related industries can provide a range of feedstocks such as woody and other cellulose containing biomass, crop residues, oil seed crops, fermentable wastes (including waste water sludge), and animal manure for bioenergy. As global supplies of fossil fuels are reduced, when carbon emissions are priced, these renewable feedstocks from agriculture will become increasingly valuable as energy sources.

Bioenergy feedstocks from agriculture can provide additional income for farmers and others in the agricultural value chain. They should be cultivated on land *less suitable* for growing wheat, barely or canola crops - thus increasing the land suited to agriculture without competing with food production.

Short-rotation forestry is suitable for sustainable production of large amounts of biomass for energy and industrial purposes by applying fast-growing tree species. The full growth potential of a tree species is realized by creating optimal water and nutrient conditions, eliminating competition by herbaceous plants and other tree species, and preventing biotic and abiotic damage.

Land for cultivation of woody bioenergy crops includes agricultural land that is no longer needed for agriculture because of overproduction; clear-cut forest land in tropical and temperate areas; and degraded land, especially in many developing countries.

The cultivation methods of short rotation forestry and other bio energy crops should be accepted from environmental, economic and even aesthetic points of view without compromising the protection of valuable natural forests by meeting needs for wood resources.

The use of short rotation forests as vegetation filters and means for bio-remediation, in which nitrogen and phosphorus in waste water and sewage are used for irrigation and fertilization in short-rotation forestry, can be of particular interest in developing countries where technically advanced purification plants are too expensive to establish. Vegetation filters also help prohibit eutrophication (nutrient pollution) of nearby streams and lakes.

Waste water treatment and reuse in rural areas is built on the concept of ecological cycles in agriculture, agricultural settlements and their links to neighbouring areas. There are countries (e.g. Sweden) where this ecocycle-concept and the preservation and restoration of surface waters, ground water and coastal areas have been established and underpinned by a solid yet flexible environmental legislation.

Biodiversity should be build into large scale planting by varying age structure and introducing open space, so that the crop is subdivided at a scale that suits the particular landscape type. Some landscapes, with particularly valuable cultural heritage, such as parkland and historic designed landscapes may be unsuitable for the introduction of coppice on any significant scale.

"We have to implement a sustainable micro-region the cooperative community of which operates a sustainable and competitive local economy, public service system and infrastructure satisfying our basic needs. At the same time we sustain our excellent natural environment and serve as a good practice for other micro-regions too" [Dinya, 2011].

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