Marginal lands for Growing Industrial Crops

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Type			**Dissemination Level**		
R	Document, report	☒	**PU**	Public	☒
DEM	Demonstrator, pilot, prototype	☐	**CO**	Confidential, only for members of the consortium (including the Commission Services)	☐
DEC	Websites, patent fillings, videos, etc.	☐			
OTHER		☐			

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1. Introduction

Marginal land rehabilitation to grow industrial crops presents a unique opportunity for delivering commitments for the Renewable Energy Directive (RED II), global climate change goals, and sustainable bio- based products without interfering with European food security. Moreover, the Common Agricultural Policy (CAP), under Pillar II, has set support measures for Less Favoured Areas (LFA), High Nature Value Farming (HNV), Areas of Natural Constraints (ANC) to prevent land abandonment.

Marginal lands are in large part attributed to agricultural land which has been abandoned. This is a major problem in terms of environmental, socioeconomic and landscape implications as it can cause uniform landscapes, higher risks of fires, reduced biodiversity adapted to man-made environments, reductions in river flows and less water in basins, loss of cultural landscapes and management techniques required for their conservation, and loss of arable land and pastures, which could be essential for the sustainable development of rural communities.

The aim of identifying ‘Good Practices’ is to understand the context of using marginal land for cropping, the state and prospects for industrial crops, the conditions framing their cultivation and the supply chains as well as their operational capacities across time and development stages. The process of identifying the ‘Good Practice’ involves gathering information on successes and failures of growing industrial crops on marginal lands in different contexts and lessons learned from them followed up with analysis of what works, what does not work and why. The ‘Good Practice’ can be assessed based on a combination of technical, environmental, economic and socio-economic criteria and indicators.

It will follow practices which rehabilitate the biophysical constraints related to the soil and water conditions of the land while improving environmental, economic and societal establishments and operational aspects of the value chain. These practices will lead a path to policy success in integrating industrial crops cultivated in marginal lands in bio-based value chains.

2. Aim of the report

The aim of this report is to provide a structured overview for an initial set of Good Practices on industrial crops grown on marginal lands as well as identify appropriate indicators for their analysis that will take place in Tasks 7.2 and 7.3.

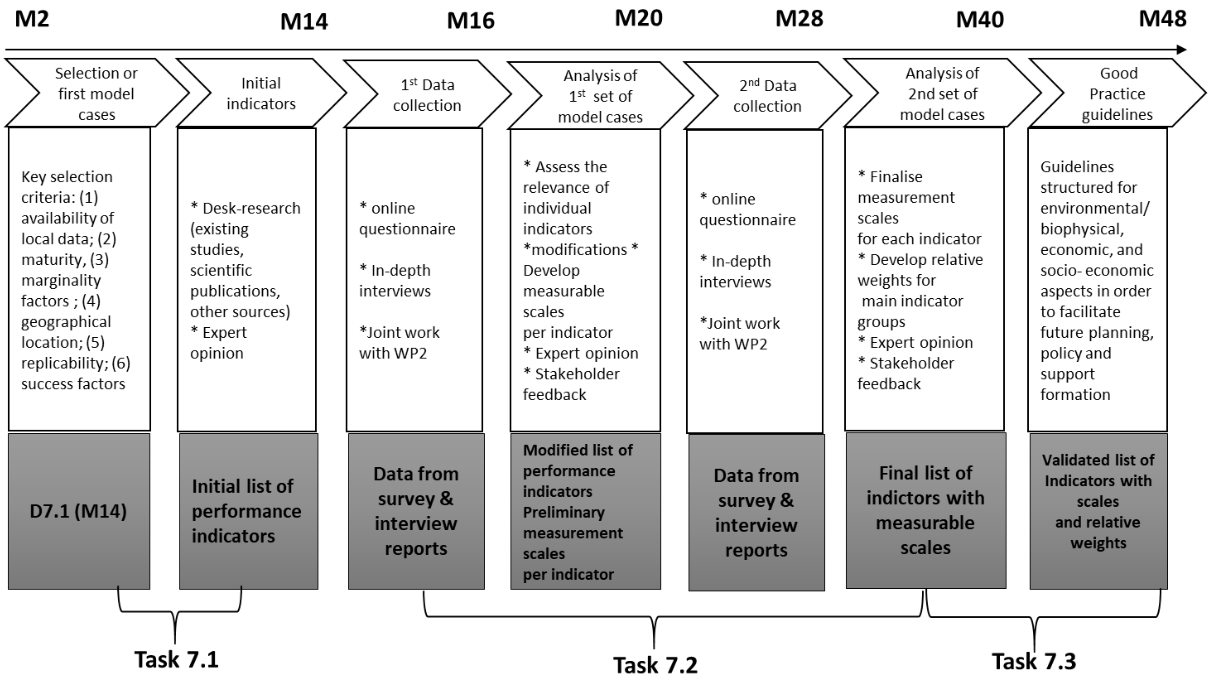


Figure 1 Methodological components in WP7

At the project proposal stage, it was anticipated that research would focus on ‘best practices’ for industrial crops in marginal land. During the first months of the work it became obvious that most of the identified cases on the ground were either at small field trial/ demonstration scale or pilot stage at regional level in one country but not replicated in other regions. In addition to that the value chain formation was not complete, from land rehabilitation to feedstock production and to manufacturing of bio-based products and/ or bioenergy. Several innovations had taken place at different steps within the chain and maturity stages but not in a complete value chain perspective. Thus, it was not feasible to narrow the sample down and choose an absolute ‘best practice’ with long term success and high transferability of the delivered outputs.

Therefore, the team came to an understanding with the project consortium that MAGIC will identify and analyse ‘Good Practices’ across value chains from different regions in Europe and further evaluate the transferability of the findings to other regions or clusters of regions/ countries with similar marginal land-ecology-climate context. The selected cases will form a representative sample of crops, climatic zones, regional profiles and bio based industrial applications.

During the project, the term ‘marginality of a region’ will also be investigated in the broader sense by including environmental, economic and social factors and not limiting it only to bio-physical constraints.
The selected ‘Good Practice’ cases will aim to provide guidance for selecting industrial crops under specific marginal conditions and designing appropriate bio-based value chains in a wider regional development context.

3. What is considered a Good Practice?

According to FAO[1]: A good practice is not only a practice that is good, but a practice that has been proven to work well and produce good results and can therefore be recommended as a model. It is a successful experience, which has been tested and validated, in the broad sense, which has been repeated and deserves to be shared so that a greater number of people can adopt it.

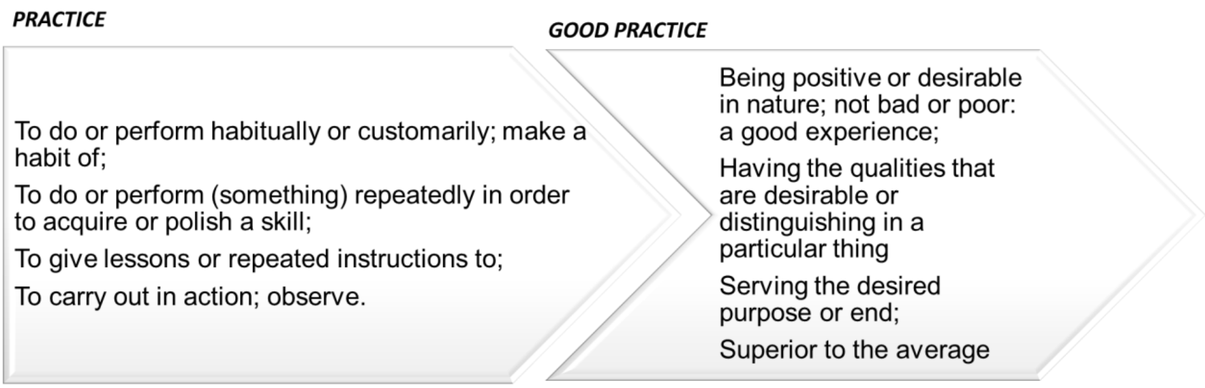


Figure 2 Definitions of 'practice' and 'good practice'

3.1 Good Practices in MAGIC

In the context of the ongoing research in MAGIC, 'Good Practice' is defined as the application of a method or technique that has shown successful results within the specific context of marginal land and industrial crops. The Good Practice examples included in this report do not necessarily show 'gold standard' examples, rather they simply provide information about what is and isn't working under certain conditions so that this knowledge can be applied to other projects.
The project team hopes that by documenting and sharing this information, others can learn from the experiences set out here to improve the outcomes of their own projects and in doing so help steer the development of industrial crops from marginal land to the right direction[2].

The term ''Good Practice'' implies that it is good when compared to other alternative course of action and that it is a practice designed to achieve some deliberative end[3]. Hence, there are three important characteristics that are associated with its development and operation:

- a comparative process,

[1] FAO (2014) Good Practices template, www.fao.org/capacitydevelopment/goodpractices/gphome/en/
[2] Rokwood (2015) Energy crops in Europe. Best practice in SRP biomass from Germany, Ireland, Poland, Spain, Sweden & UK
[3] Bretschneider, S., Marc-Aurele Jr., F. J., & Wu, J. (2004) ''Best Practices'' Research: A Methodological Guide for the Perplexed. In JPART 15:307–323. doi:10.1093/jopart/mui017

- an action, and
- a linkage between the action and some outcome or goal.

In MAGIC, the term is applied across the value chain and within the overall framework of regional development and addresses ’Good Practice’ regions that have one or more successful projects with industrial crops grown on marginal land for bio-based products.

3.2 Development stages of a Good Practice in MAGIC

Rehabilitation of marginal land with industrial crops is not a common practice and there are very few and recent examples worldwide. The development of an industrial crop value chain in marginal land passes through three main stages, typically taking a few years to reach maturity. The challenges at the initiation of the chain differ from those during the mature stage. Hence it makes sense for the research performed in MAGIC to distinguish the phases in the development path and analyse the respective operational capacities that should be in place for successful implementation. This dimension will also be further analysed within MAGIC. The considered development stages are:

- Initial stage and take off: Introducing industrial crops in the regional planning agenda and creating the policy, socio-economic and R&D landscape for the establishment and operation of the value chains.
- Drive to maturity: The first crops are cultivated by farmers and sold to the market. The value chains grow with the addition of new farmers, farmer cooperatives, companies, regional infrastructure (machinery, storage facilities and transport networks, etc.) has improved, and the activities attract both private and public funding.
- Maturity: The value chains can produce crops at an extensive scale and operate with well-functioning market mechanisms.

3.3 Categorisation of Good Practices

The Good Practices in Magic will be further grouped to:

- Practices improving land reclamation and establishment of the industrial crops
- Practices improving operational aspects of the value chain; (at value chain level)
- Practices leading to policy success in integrating industrial crops cultivated in marginal lands in bio-based value chains (at EU, Member State and regional level).

In order to appropriately evaluate the Good Practices, work is ongoing from Month 14 and it will be reported in Deliverable 7.2: Analysis of Good Practices (M40). This work will build on:

- Benchmarking – learning from and through the experience of others.
- Standards – Good practice through achievement of standards.

4 Selected Good Practices

A first set of Good Practices for industrial crops grown on marginal lands have been identified during months 1-6, in collaboration with the project partners, and stakeholder interview input from EIP AGRI, Copa Cogeca, etc. An online survey (see Annex I) for interest was launched in M5 (for two months) on the project website and distributed to EU regions and clusters in order to collect a broad set of cases across European regions. The rationale behind the survey has been to ensure that the good practices identified were selected among a variety of cases that extend beyond the knowledge and capacities of the project consortium and also take into account the multi-actor approach and ensure a participatory process across the selection, mapping, analysis and formation of best practices and recommendations. All proposals received will be analysed and feedback will be compiled in factsheets.
The work will also take into account the multi-actor approach and ensure a participatory process across the selection, mapping, analysis and formation of best practices and recommendations.

For this report, a set of studies has been selected based on the following criteria[4]:

- Effective and successful:
  A "Good Practice" has proven its strategic relevance as the most effective way in achieving a specific objective; it has been successfully adopted and has had a positive impact on individuals and/or communities.
- Maturity:
  Both well-developed and developing
- Technically feasible:
  Technical and geographic feasibility is the basis of a "good practice". It is easy to learn and to implement. Mediterranean north & south; Atlantic; Continental & Boreal (Magic geographical/ climatic zones in Europe).
- Availability of local data:
  Local research teams are working on the Good Practice cases and are able to provide input during the course of the research work.
- Environmentally, economically and socially sustainable:
  A "good practice" meets current research needs, in particular addressing how to use industrial crops as a means to rehabilitate marginal land from either biophysical and/ or social constraints.
- Inherently participatory:
  Participatory approaches are essential as they support a joint sense of ownership of decisions and actions.
- Replicable and adaptable:
  A "good practice" should have the potential for replication and should therefore be adaptable to similar objectives in varying situations.

[4] FAO (2014) Good Practices template. www.fao.org/capacitydevelopment/goodpractices/gphome/en/

- Reducing disaster/crisis risks, if applicable:
  A "good practice" contributes to disaster/crisis risks reduction for resilience.

The first set of selected Good Practices for this report are outlined below in Table 1.

Table 1 First set of selected Good Practices

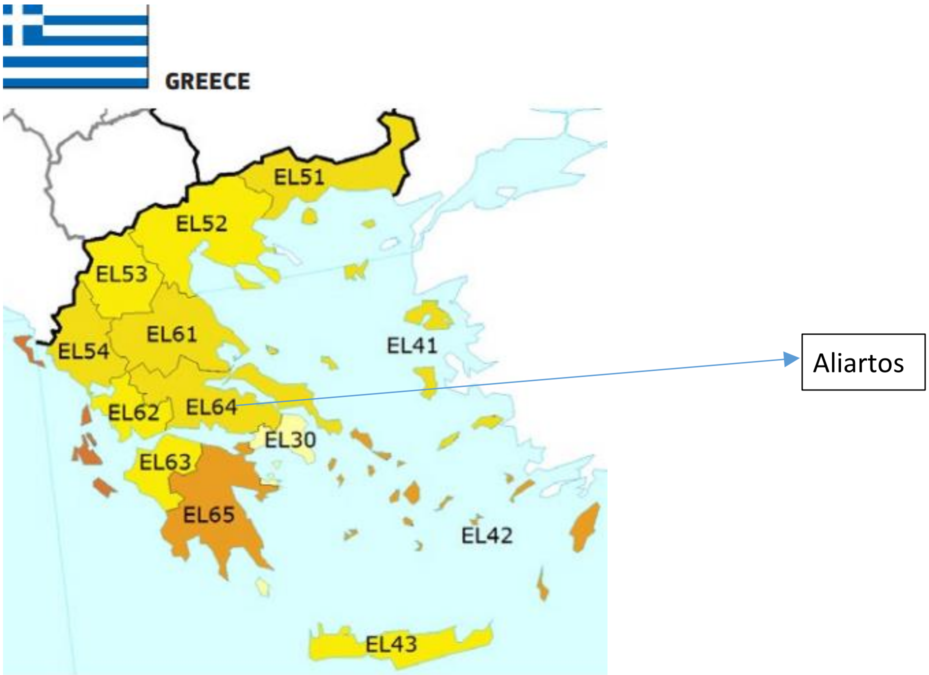
Geoclimatic Zones	Case No.	Dominant Biophysical Marginal factors	Country	Selected Region	Implementing Institution	Selected Industrial Crops		
						Lignocellulosic	Carbohydrat	Oil
Zone 1: Mediterranean	1	Adverse rooting- shallow soil depth	Greece	Aliartos	CRES	Switchgrass		
		Low soil fertility and light sandy soil				Giant reed		
	2	Adverse rooting-stoniness, heavy clay, shallow soils	Greece	East Macedonia & Thrace	DAMT	Black locust		Sunflower
	3	Adverse chemical conditions- Contamination	Italy	Sardinia	CREA/FAO	Giant reed and Cardoon		
	4	Adverse Terrain-steep slope and dryness	Italy	Catania, Sicily	UNICT	Giant reed and Miscanthus		
	5	Adverse chemical conditions-Contaminatiion	Italy	Lazio	IBAF-CNR	Poplar		
	6	Adverse Climate-Dryness and low water availability Low soil fertility -poor and sandy soil	Spain	Soria	CEIMAT	Rye and Tall wheatgrass		
	7	Low soil fertility-sandy soil	Spain	Castilla-La Mancha	ALCAMANCHA Cooperatives			Lavender
Zone 3: Continental and Boreal	8	Adverse rooting-organic and sandy soils	Germany	Lusatia Brandenburg	IBAF-CNR	Black locust		
		Low soil fertility				Popalr		
	9	Adverse Terrain and Adverse climate	Hungary	Middle- Tisza	WWF-Hungary	Black Locust		
	10	Adverse rooting-heavy clay, stonniness Excessive soil moisture- inconsistent soil moisture	Latvia	Skriveri	SILAVA	Perennial grasses and legumes between the trees		
	11	Adverse rooting and low soil fertility Excessive moisture-prone to flooding	Ukraine	Volynska and Lviv	Salix Energy Ltd	Willow		
	12	Low soil fertility	Ukraine	Kyiv oblast, Ivankiv	FORBIO project	Miscanthus		
Caribean	13	Adverse soil conditions- soil acidity and low organic content	Dominican Republic		Bioenergy Crops Ltd	Napier Grass		

The cases represent two of the agro-climatic zones in MAGIC: Mediterranean and Continental- Boreal from the European region and Caribbean region. They cover all the biophysical constraints under study in the project and include lignocellulosic and oil crop species.

The final set of Good Practice cases will include all agro-climatic zones from the project research work and carbohydrate crops.

Case 1: Switchgrass & giant reed in Greece

Region +NUTS code: Aliartos, Central Greece NUTS code: EL64



Greece NUTS2 map[5]

Demonstration/Implementation level: Local/Regional/National

Size of the cultivated land: < 50 Hectares

Climate: Mediterranean (Zone 1 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: Centre for Renewable Energy Sources and Saving (CRES), Greece

Introduction of the region and the 'Good Practice' project: Aliartos region has hot summer and wet winter months. The region has Southern Mediterranean climatic conditions with an annual mean temperature of 18.4 +/- 0.6 Celsius and precipitation mostly concentrated in winter months. Two switchgrass fields had been established; the first in 1998 with a total size of 0.35 ha in the view of Switchgrass project (1998-2001)[6] and the second in 2002 with a total size 0.25 ha in the view of Bioenergy Chains project (2002-6)[7]. Both of these trials had received funding from the OPTIMA project (2011-15)[8]. They are still on-going and are currently being funded by the MAGIC project. The soil profile at the site is sandy clay loam tex-

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[5] European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491, accessed on 15th October 2018

[6] Switchgrass for Energy; www.switchgrass.nl

[7] Bioenergy Chains project, www.cres.gr/bioenergy_chains

[8] OPTIMA (Optimisation of perennial grasses for biomass production in Mediterranean Area) was the Horizon2020 EU funded research project focusing on biotechnology and they were researching on species grown in marginal and abandoned agricultural lands in Europe.

ture up to the depth of 0.82m and just sandy in the deeper layer. The soil is low in organic matter and pH is alkaline.

Giant reed started in 2002 and on-going and field size is 0.28 ha. This trial had been established in the framework of Bioenergy chains project from 2002-6 and received funding from 2011-5 from OPTIMA project, while currently is being funded by MAGIC.

Industrial Crops: Switchgrass (*Panicum virgatum L*.) and Giant reed (*Arundo donax* L.)

Potential as an Industrial crop:

Switchgrass (*Panicum virgatum L*.) is a perennial grass native to North America and has a wide range of climatic adaptability and it can be propagated by seeds. It has very well-developed rooting system as it can reach up to the depth of 10 feet making it adaptable to the drought conditions and tolerant to severe water stress conditions. It grows up to 2.5m in height and can produce the maximum yield of 14 odt/ha/yr[9]. Switchgrass has a good potential to be biomass feedstock because it has high net energy production per hectare, low productions costs, low nutrient requirements, wide geographical adaptation, low ash content and adaptation to marginal soils and increased potential for carbon storage in soil (Christian and Elbersen, 1998; Sanderson et al., 1996; Samson and Omielan, 1992 Cited[10] in Alexopoulou, E. et al, 2017). Therefore, growing switchgrass on marginal and low productive agricultural lands can increase the farmers income through access to opportunities on bioenergy and bio-products markets.

Giant reed (*Arundo donax* L.) is the perennial lignocellulosic crops which is native to Eastern and Southern Asia. It is selected as one of the most promising energy crops based on the Agronomic Feasibility Study[11] performed by CREA and Biochemtex together with FAO. It is drought resistant with sterile seeds and is saline soil tolerant making it suitable for marginal soil conditions. It is considered as cost-effective energy crops because it can be harvested annually for decades after planting.

Marginality Factors: Aliartos region has shallow soil depth, low fertility and light sandy soils as its main marginality factors. The land was left fallow for two decades. In addition to this, there are other biophysical, economic, environmental and social marginality factors which applies to the project region and marginality level also varies as shown in table below.

[9] https://articles.extension.org/pages/26635/switchgrass-panicum-virgatum -for-biofuel-production#Current_Potential_for_Use_as_a_Biofuel. Accessed on 6th Nov, 2018

[10] Alexopoulou, E., et al. (2017). "Long-term studies on switchgrass grown on a marginal area in Greece under different varieties and nitrogen fertilization rates." 107: 446-452.

[11] Pulighe, G., Bonati, G., Fabiani, S., Barsali, T., Lupia, F., Vanino, S., Nino, P., Arca, P. & Roggero, P. P. (2016). Assessment of the agronomic feasibility of bioenergy crop cultivation on marginal and polluted land: A GIS-based suitability study from the Sulcis area, Italy, *Energies*, 9(11): 895.

			Marginality level		
Key Assets	Criteria	Indicators	High	Medium	Low
Bio-physical	Soil	Limitation in rooting	x	x	
		Low Fertility	x	x	
Economic	Productivity	Yields	x	x	
Environmental	Water quality	Water Availability	x	x	
	Soil quality	Organic content and nutrient balance	x	x	
Social	Demography of population	Population age	x	x	

Project Timeline: Start: 1998 and 2002 (switchgrass for energy), 2002-2006 (bioenergy chains) and OPTIMA (2011-2015) and from 2017 and onwards by MAGIC - End: Ongoing

Funding source: €110,000 from Switchgrass for Energy project, €500,000 from Bioenergy Chains and €300,000 from OPTIMA (total budget of the projects). In reality each field needed €10,000 to €15,000 for continued maintenance and research. The cost was higher for all these trials at the establishment year (in the case of giant reed, cost could be two times higher with establishment by seeds).

Success elements (targets achieved) and Failures (obstacles and challenges faced): A success point was to have long-term yields data for 20 years for switchgrass and 16 years for giant reed. This was quite difficult since funding was available only for few years. What has not been achieved so far is the mechanical cultivation for these crops since these fields were established by hand and all manual work was done by hand. A second success element was the operationalisation of pellet production.

Innovation: The fields of switchgrass were the first established in Greece. Moreover, all these fields (giant reed and switchgrass) were the first established on a fallow marginal land.

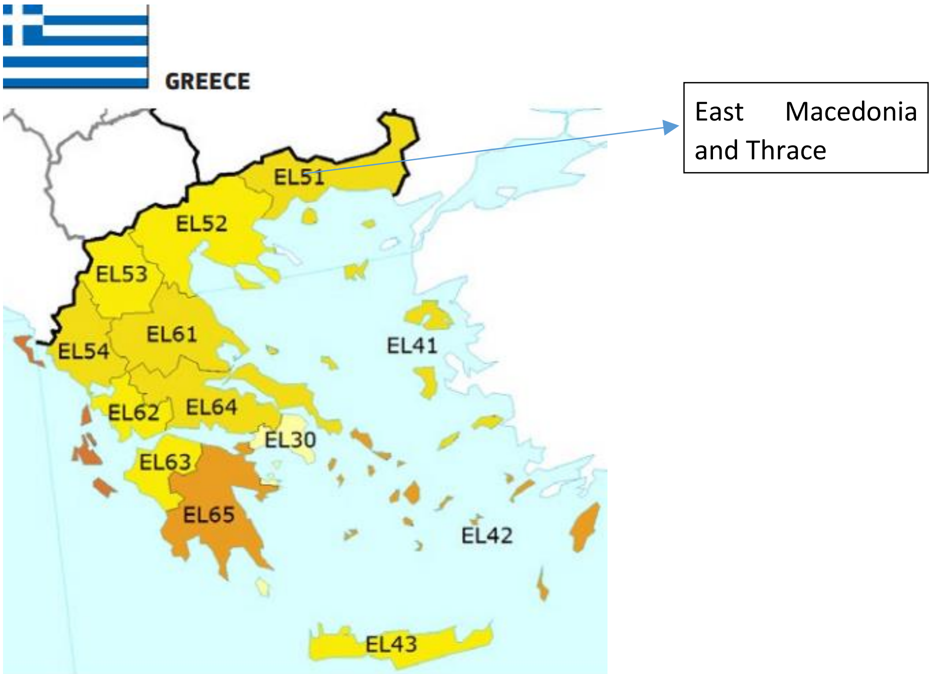
Greece is a moderate innovator according to the European Innovation Scoreboard report 2017[12]. When analysed in a holistic manner including innovation performances in technological, service, commercial, managerial, public sector and social systems, while the innovation performance for most of the region has increased, the EL64 region's innovation has decreased by 1%.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Research Institute, University

[12] EU COMMISSION (2018) "European Innovation Scoreboard 2017: Country Profiles ". Retrieved 10th October, 2018, from https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en.

Case 2. Black locust & sunflower in Greece

Region +NUTS code: East Macedonia & Thrace Forest Services Region, NUTS code: EL51



Greece NUTS2 map[13]

Demonstration/Implementation level: Regional

Size of the cultivated land: ≥1,000 Hectares

Climate: Mediterranean (Zone 1 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: Decentralised Administration of Macedonia and Thrace (DAMT).

Introduction of the region and the 'Good Practice' project: Thrace region has Mediterranean semiarid climatic conditions with dry summer and wet winter. This region has abandoned agricultural land which is currently grassland and pastureland. The project sites are forested areas surrounding the agricultural lands of the Thrace region. These forest areas were identified as marginal sites suitable for biomass production. The biophysical constraints of the region are limiting rooting conditions because of shallow soils with hard rock very close to the surface. This region also has sleep slopes indicating adverse terrain conditions. Pine, oak and black locust are the commonly found species in the region.

Greece is a mountainous country with only 30% of land suitable for agriculture. Despite this,

[13] European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491 accessed on 15th October 2018

agriculture sector accounts for more than 5% of the GDP which is three times more than EU average of 1.8%. According to the report[14] prepared by SEEMLA project 27% of the arable agricultural land in the mountainous region of Greece has been abandoned between 1961 and 2000 because of low productivity and soil depth being less than 30 cm, limiting the root growth. Therefore, using these marginal sites by establishing fast growing plantations is seen as a promising solution for Greece.

Industrial Crops: Black locust (*Robinia pseudoacacia*) and Sunflower (*Helianthus annuus)*

Potential as an Industrial crop:

Black locust is a fast growing, lignocellulosic crop which is planted worldwide. It is native to south-eastern region of United States but introduced to North America, Europe, East Asia, Africa, New Zealand and Australia[15]. Chinese Virtual Herbarium (CVH, 2015) databases show that black locust has naturalised in approximately 35 countries and is considered an invasive species in countries such as Austria, Czech Republic, Germany, Hungary, Slovenia and Switzerland. New Zealand[16]. They can tolerate diverse and extreme soil conditions like low organic content, acidic, alkaline, stony and toxic contamination. It is the first invasive species used in Greece for the restoration of degraded agricultural lands. After 20 years of black locust plantation in the Macedonia and Northern Greece area, the soil organic content was increased by 1.3-3 times and nitrogen level was increased 1.2-2.5 times, similarly P and K level were also significantly higher[17]. However, its efficient N-fixation ability and high N-content litterfall and litter decomposition have led to contamination of floodplains and rivers, and ultimately degradation of riparian ecosystems[18] by coastal eutrophication[19]. Black locust, when compared to first generation crops like sugar beet and rapeseed, has shown to contribute more to GHG emission reduction and has higher net energy yields and better resource use efficiencies[20]. All these attributes, apart from possible negative impacts on riparian zones, make black locust a low impact crop that can rehabilitate abandoned agricultural lands[21]. According to the report[22] by the SEEMLA project, black locust is seen as

[14] HANZHENKO, O. 2016. SEEMLA: Catalogue for bioenergy crops and their suitability in the categories of Marginal lands [Online]. Available: http://seemla.eu/en/2016/09/30/catalogue-for-bioenergy-crops-and-their-suitability-in-the-categories-of-magls/ [Accessed 2018].

[15] BAŞNOU, C. 2006 Robinia pseudoacacia factsheet. Delivering Alien Invasive Species Inventories Europe DAISIE [Online]. Available: http://www.europe-aliens.org/pdf/Robinia_pseudoacacia.pdf [Accessed 24th October 2018].

[16] LI, G., ZHANG, X., HUANG, J., WEN, Z. & DU, S. 2018. Afforestation and climatic niche dynamics of black locust (Robinia pseudoacacia). Forest Ecology and Management, 407, 184-190.

[17] PAPAIOANNOU, A., CHATZISTATHIS, T., PAPAIOANNOU, E. & PAPADOPOULOS, G. 2016. Robinia pseudoacacia as a valuable invasive species for the restoration of degraded croplands. Catena, 137, 310-317.

[18] BUZHDYGAN, O. Y., RUDENKO, S. S., KAZANCI, C. & PATTEN, B. C. 2016. Effect of invasive black locust (Robinia pseudoacacia L.) on nitrogen cycle in floodplain ecosystem. Ecological modelling, 319, 170-177.

[19] VAN WIJNEN, J., IVENS, W. P., KROEZE, C. & LÖHR, A. J. 2015. Coastal eutrophication in Europe caused by production of energy crops. Science of the Total Environment, 511, 101-111.

[20] DE VRIES, S. C., VAN DE VEN, G. W. & VAN ITTERSUM, M. K. 2014. First or second generation biofuel crops in Brandenburg, Germany? A model-based comparison of their production-ecological sustainability. European journal of agronomy, 52, 166-179.

[21] Ibid.

[22] HANZHENKO, O. 2016. SEEMLA: Catalogue for bioenergy crops and their suitability in the categories of Marginal lands [Online]. Available: http://seemla.eu/en/2016/09/30/catalogue-for-bioenergy-crops-and-their-suitability-in-the-categories-of-magls/ [Accessed 2018].

an important bioenergy crops which can be grown in marginal lands in Europe because it is salt tolerant, needs less soil moisture and soil fertility and can make soil fertile by fixing nitrogen.

Sunflower is an oil crop widely known for its stable oil composition. It can be grown in variety of soil conditions but grows best in well-drained soil with high water-holding capacity. It is drought tolerant and resistant to salinity. It has a deep root system making it efficient in stratified use of soil resources[23] and has high water use efficiency[24] compared to rapeseed and crambe. It is grown for phytoextraction of heavy metals like lead and cadmium in contaminated lands[25]. At present Romania and China are the main producers of sunflower (FAO, 2017). It is also widely grown in Eastern European countries like Russian Federation, Ukraine, Turkey, Bulgaria, Romania, Moldova, Serbia, and others) and North American countries like USA and Canada.

Marginality factor: East Macedonia and Thrace region has adverse rooting as marginality conditions like stoniness, heavy clay, shallow soils. In addition to this, there are other bio-physical, economic, environmental and social marginality factors which applies to the project site and marginality level also varies as shown in table below.

			Marginality level		
Key Assets	Criteria	Indicators	High	Medium	Low
Bio-physical	Terrain	Adverse Terrain	x		
	Climate and soil	Excessive wetness		x	
Economic	Funding	Annual payment	x		
	Rent	Land rent		x	
Environmental	Soil	Soil erosion	x		
	Air	Air quality (Emission)			x
	Climate change	GHG emission related to iLUC		x	
Social and Institutional	Awareness	Knowledge about marginal lands and its prospects	x		
	Demography of population	Population, age, density, institutional capacity		x	

Project Timeline: Start: 01/2016 - End: 12/2018

Funding source: EU fund: €1,500,000 - National Public fund: €5,000 - Total fund: €1,505,000

Success elements (targets achieved) and Failures (obstacles and challenges faced):

The project site has a well-established black locust plantation proving that this crop can be grown in marginal sites affected by adverse terrain conditions.

[23] ZEGADA-LIZARAZU, W. & MONTI, A. 2011. Energy crops in rotation. A review. Biomass and Bioenergy, 35, 12-25.
[24] ANDERSON, R. L., TANAKA, D. L. & MERRILL, S. D. 2003. Yield and water use of broadleaf crops in a semi-arid climate. Agricultural water management, 58, 255-266.
[25] ZHAO, X., MONNELL, J. D., NIBLICK, B., ROVENSKY, C. D. & LANDIS, A. E. 2014. The viability of biofuel production on urban marginal land: An analysis of metal contaminants and energy balance for Pittsburgh's Sun-flower Gardens. Landscape and Urban Planning, 124, 22-33.

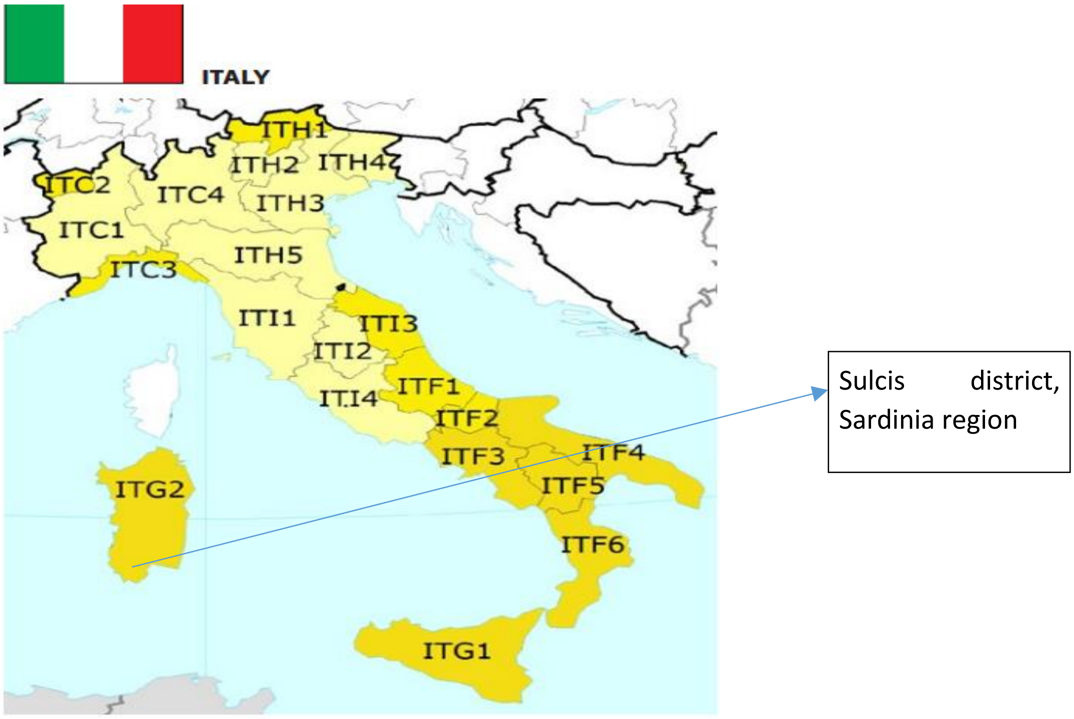
Innovation: According to the European Innovation Scoreboard 2018[26] report, the East Macedonia region of Greece is considered as a moderate innovator when analysed in a holistic manner analysing its innovation performances in technological, service, commercial, managerial, public sector and social systems. The region's innovation has increased over time.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Government - Agricultural extension services

[26] EC, E. C. 2018. European Innovation Scoreboard 2017: Country Profiles [Online]. Available: https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en [Accessed 10th October 2018].

Case 3: Giant reed & cardoon in Italy

Region +NUTS code: Sulcis district**,** Sardinia region/ +NUTS code: ITG2



Italy NUTS2 map[27]

Demonstration/Implementation level: Regional

Size of the cultivated land: Target area is 35.745 ha of which 18.706 ha currently agricultural is yet to be considered underutilised (because contaminated or bordering contaminated sites).

Climate: Mediterranean (Zone 1 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: FORBIO Project implemented by CREA (Research Centre for Agricultural Policies and Bioeconomy) and FAO (Food and Agriculture Organisation of the United Nations)

Introduction of the region and the 'Good Practice' project:

FORBIO project case study area is the Sulcis district which is in the South-west of Sardinia Island. The region has Mediterranean semi-arid climatic conditions. In this study site contaminated land categorised as SIN (Sites of National Interest) are found. The area has been polluted by industrial flumes of coal power plants, bauxite and aluminium production plants and mining activities. The soil in the region has high contamination of heavy metals such as lead, cadmium, and zinc, however agronomic feasibility carried out in the context of the FORBIO project shows that these regions are suitable for biomass production. According

[27] (Source: European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491 accessed on 19th October 2018)

to the FORBIO Deliverable 3.3 report[28], a total of 18,706 ha of current agricultural land is categorised as underutilised either because it is contaminated or borders these contaminated sites. The project is an attempt to cultivate dedicated energy crops on contaminated soils to ameliorate the land.

Industrial Crops: Giant reed (*Arundo donax* L.) and Cardoon (*Cynara cardunculus*)

Potential as an Industrial crop:

Giant reed (*Arundo donax* L.) is a perennial lignocellulosic crop which is native to Eastern and Southern Asia. It is selected as one of the most promising energy crops based on the Agronomic Feasibility Study[29] performed by CREA and Biochemtex. It is drought resistant with sterile seeds and high salinity tolerance making it suitable for marginal soil conditions. It is considered a cost-effective energy crop because it can be harvested annually for decades after planting with consistently-high yields. In Deliverable 2.1[30], the FORBIO project assessed the expected yields of giant reed under irrigated and rainfed conditions in the case study area. Irrigated giant reed can yield steadily some 25 tons of dry biomass per hectare per year (t ha-1 yr-1) in the Sulcis, whereas giant reed production under rainfed conditions reports yields of around 10 t ha-1 yr-1. According to the outcomes of Deliverable 2.1 and 2.2[31] of the FORBIO project, giant reed is also seen as a potential feedstock for lignocellulosic ethanol production. Giant reed is a low input crop characterised by high water use efficiency and relevant carbon storage potential. The techno-economic feasibility report[32] produced in the context of FORBIO also concluded that giant reed can produce advanced biofuels as the technological readiness level of the plant producing lignocellulosic ethanol from giant reed is TRL 8. Giant reed is also known to have phytoremediation capacity with phytoextraction and accumulation in the hypogeal part[33].

Cardoon is a perennial lignocellulosic energy crop which is also short listed as a promising bioenergy crop. Among perennial crops, cardoon shows high yields (20 t/ha) and its adaptability for Mediterranean climatic conditions makes it suitable for the region. Though it is native to Mediterranean region, it thrives very well in the temperate region with semiarid and sub humid climatic conditions. It is a rainfed crop therefore suitable for most contaminated areas where irrigation is not possible. Cardoon has stable biomass yields, low nutrient input and fermentable sugars making it a potential bioenergy crop that can be grown on marginal sites.

Marginality Factors: For the region one of the main biophysical marginality factor is the contaminated soil conditions and water availability and its efficient use are the limiting factors.

[28] MORESE, M. M., COLANGELI, M. & TRAVERSO, L. 2018. FORBIO D3.3 Final report on the sustainability assessment of the selected advanced bioenergy value chains in all the case study sites. FAO.
[29] PULIGHE, G., BONATI, G., FABIANI, S., BARSALI, T., LUPIA, F., VANINO, S., NINO, P., ARCA, P. & ROGGERO, P. P. 2016. Assessment of the agronomic feasibility of bioenergy crop cultivation on marginal and polluted land: A GIS-based suitability study from the Sulcis area, Italy. *Energies,* 9**,** 895.
[30] MORESE, M. M., COLANGELI, M. & TRAVERSO, L. 2018. FORBIO D3.3 Fnal report on the sustainability assessment of the selected advanced bioenergy value chains in all the case study sites. FAO.
[31] BARSALI, T. 2018. FORBIO D2.2 Feasibility study italy techno-economic feasibility. Biochemtex.
[32] Ibid.
[33] BARBOSA, B., BOLÉO, S., SIDELLA, S., COSTA, J., DUARTE, M. P., MENDES, B., COSENTINO, S. L. & FERNANDO, A. L. 2015. Phytoremediation of heavy metal-contaminated soils using the perennial energy crops Miscanthus spp. and Arundo donax L. *BioEnergy Research,* 8**,** 1500-1511.

			Marginality level		
Key Assets	Criterias	Indicators	High	Medium	Low
Bio-physical	Soil	Limitation in rooting			x
		Low Fertility		x	
		Excessive wetness			x
		Contaminated soil		x	
	Terrain	Adverse terrain			x
	Climate	Adverse Climate		x	
Economic	Productivity	Crop Yield	x		
	Accessibility	Infrastructure		x	
	Land rent	(Revenue made each year within a project time)			x
Environmental	Resource Use	Conservation of Biodiversity			x
		Land use			x
	Water	Water availability	x		
		Water use efficiency	x		
	Soil	Soil erosion		x	
		Soil organic and nutrient content		x	
	Climate change	GHG emission related to iLUC			x
		GHG reduction			x
Social and Institutional	Socio-economic	Accessibility	x		
		Infrastructure	x		
	Policy	Presence of policy instrument (Effectiveness of policy)	x		
		Consistency of policy	x		
	Population demography	Population, age density and institutional capacity		x	
	Cultural	Lack interest and mistrust about prospects of marginal lands	x		x
	Awareness	Knowledge on availability and prospects of marginal lands			

Project Timeline: Start: 01/2016 - End: 12/2018

Funding source: €1,941,581 - Supported by European Union’s Funding under the Horizon2020 research and innovation framework.

Success elements (targets achieved) and Failures (obstacles and challenges faced): The case study of giant reed and cardoon in Sardinia, Italy provides a comprehensive agronomic and technical feasibility understanding of growing these crops as bioenergy crops in the highly contaminated soil conditions. The project strengthens the idea that energy crops can be successfully grown on marginal lands providing substantial benefits in terms of environmental impacts and socio-economic issues and supporting ecosystem services compared to intensive monocropping systems. A full landscape design analysis with field research data is needed prior to cultivating a specific crop at a specific location, considering the complex landscape examined. In fact, a pilot investigation with GIS data focusing on the most contaminated area, revealed that the available surface is approximately 1000 ha, falling within an unequipped area for irrigation, thus most suitable for rainfed crops such as those identified in this study. Regarding the agronomic feasibility, one obstacle and challenge is the availability of water for irrigation, considering the frequent dry seasons typical of Mediterranean areas, but also the inefficient irrigation infrastructures (e.g. losses of irrigation networks up to 65%). Another challenge is the full involvement of stakeholders such as farmers.

Innovation: An innovation of the project was the application of an adapted version of the GBEP Sustainability Indicators for Bioenergy[34] developed for the FORBIO project. The assessment was carried out through a purpose-built calculator developed by FAO. The Measurement of the tailored set of sustainability indicators for bioenergy based on the specific conditions of the study area was based on a harmonised data collection campaign. The approach to sustainability is structured as the analysis of the difference in impacts caused by two (or more) reference scenario projections: baseline vs target projections. For each indicator, there is the projection into the future of the conditions expected without the bioenergy development (i.e. baseline scenario) and with the addition of the bioenergy development (i.e. target scenario), according to the following formula: Iv=TSv-BSv, where Iv is the Indicator Value, TSv is the Target Scenario Value and BSv is the Baseline Scenario value.

The impact that the hypothetical value chain may have on the environmental, social and/or economic features of the case study area were defined as the difference between the two values. This innovative approach represents a first-of-its-kind methodology to produce several testing scenarios for the evaluation of a number of variables which are inherently participating in the definition of sustainability of bioenergy value chains. Effects of informed decisions, policy choices and related actions in the field, can be safely evaluated with this first-screening type of decision making support tool and methodology.

Italy is moderate innovator according to the European Innovation Scoreboard report 2017[35]. When analysed in holistic manner their innovation performances in technological, service, commercial, managerial, public sector and social system, the innovation performance for the ITG2 region has decreased by 1%.

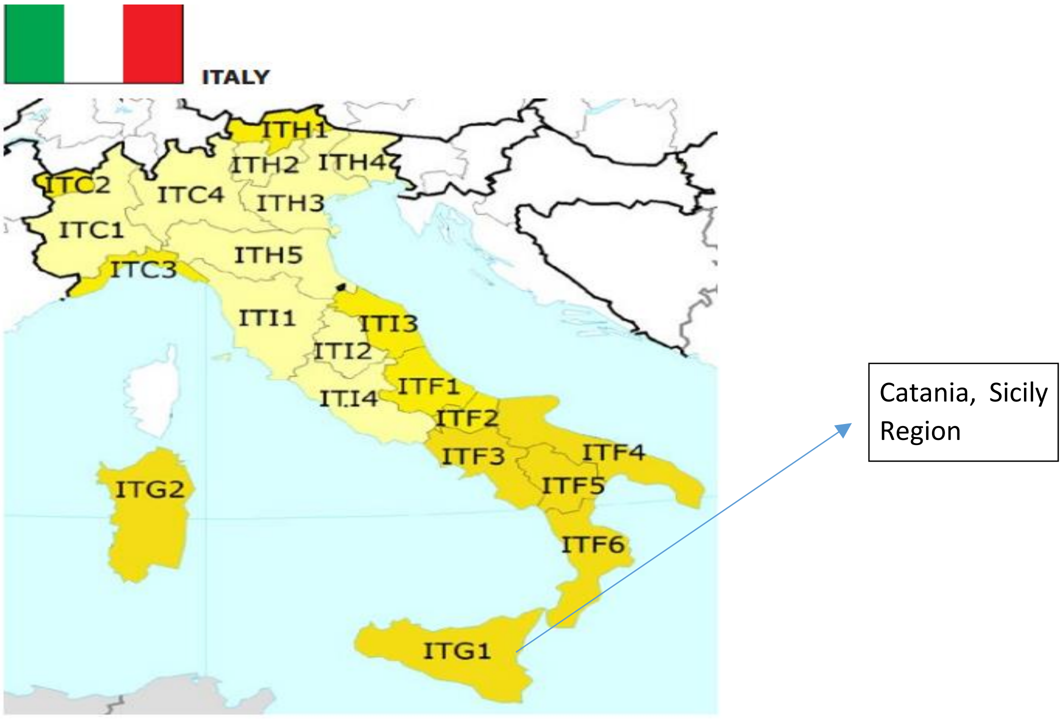
Stakeholders Involvement in the demonstration and implementation of the Good Practices: Research Institutions/Universities/ Bio-based Industries and Business/Farmers/

[34] http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf

[35] EC, E. C. 2018. European Innovation Scoreboard 2017: Country Profiles [Online]. Available: https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en [Accessed 10th October 2018].

Case 4: Perennial grasses in Italy

Region +NUTS code: Catania, Sicily region/ NUTS code: ITG1



Italy NUTS2 map[36]

Demonstration/Implementation level: Regional

Climate: Mediterranean (Zone 1 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: University of Catania (UNICT)

Introduction of the region and the 'Good Practice' project: Sicily is largest Italian region by area and 96% of Sicily's land is rural. Sicily is losing its population due to emigration of young and productive populations to other parts of the country. According to the research[37] done Selvaggi et al., 2017 on the principles of Biogasdoneright in the case of Sicily's agriculture, some perennial crops when grown under crop rotation schemes can offer agronomic, environmental, and socio-economic benefits to Sicilian agriculture. The environmental impact study[38] and life cycle assessments[39] conducted under the OPTIMA project shows that

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[36] Source: European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491 accessed on 19th October 2018

[37] Selvaggi, R., Valenti, F., Pappalardo, G., Rossi, L., Bozzetto, S., Pecorino, B., & Dale, B. E. (2018). Sequential crops for food, energy, and economic development in rural areas: the case of Sicily. *Biofuels, Bioproducts and Biorefining*, *12*(1), 22-28.

[38] Fernando, A. L., Costa, J., Barbosa, B., Monti, A., & Rettenmaier, N. (2018). Environmental impact assessment of perennial crops cultivation on marginal soils in the Mediterranean Region. *Biomass and Bioenergy*, *111*, 174-186.

the cultivation of perennial crops on Mediterranean region does not have negative environmental impacts on a global scale and provides benefit to the soil conditions, although it may contribute to the depletion of water resources. In addition, if perennial crops are used for stationary heat and power generation they have the potential for climate change mitigation and non-renewable energy savings as long as that necessary boundary conditions and recommendations are followed through with.

Therefore, there are some good practice examples taken from OPTIMA (Optimisation of perennial grasses for biomass production in Mediterranean Area) project to highlight the positive impacts of perennial grasses grown in marginal land conditions.

Industrial Crops: Perennial grasses like miscanthus, giant reed and switchgrass.

Potential as an Industrial crop: Miscanthus (*Miscanthus x giganteus*) plantation is productive for 15 years and can be harvested every year at an average yield of about 10 t d.m./ha[40]. Miscanthus does not require a big input of fertilisers due to good nutrient use efficiency (the maximum quantity of nitrogen is between 50 and 70 kg N/ha/year[41]. Giant miscanthus is disease resistant and can grow in cold temperature in wet/heavy soil conditions. It can maximise yield by utilising up to 900 mm/year[42]. Miscanthus is suitable for biomass production because its lignocellulosic yields are high. It has low moisture content at harvest (10-25%), low free sugar and nitrogen content and high lignin content. All these traits make it suitable for thermochemical conversion to biofuel. Field trials[43] in Midwestern United States have shown that giant miscanthus biomass yields are higher than traditional switchgrass varieties. Therefore, as supported by other researches across US, it is suitable for use as a feedstock for heat and electricity generation[44]. Miscanthus growth is restricted in moderate (9.8dS/m) saline soil condition and in extreme (5dS/m) conditions, plants do not survive[45]. The root system of miscanthus can stand periodic low temperature (up to -23°C) and can penetrate at the depth of 2 meters allowing effective use of the available moisture**.**

Giant reed (*Arundo donax* L.) is a perennial lignocellulosic crop which is native to Eastern and Southern Asia. It is selected as one of the most promising energy crops based on the

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[39] Schmidt, T., Fernando, A. L., Monti, A., & Rettenmaier, N. (2015). Life cycle assessment of bioenergy and bio-based products from perennial grasses cultivated on marginal land in the Mediterranean region. *BioEnergy Research*, *8*(4), 1548-1561.

[40] NIXON, P. & BULLARD, M. 2001. Planting and growing Miscanthus, best practice guidelines. Department for Environmental, Food & Rural Affairs (DEFRA) Publications.

[41] GELETUKHA, G., ZHELIEZNA, T. & TRYBOI, O. 2014. Prospects for the growing and use of energy crops in Ukraine. UABio Position Paper, 30.

[42] Ibid.

[43] https://articles.extension.org/pages/26625/miscanthus-miscanthus-x-giganteus-for-biofuel-production#Current_and_Potential_Use_as_a_Biofuel

[44] HEATON, E. A., DOHLEMAN, F. G. & LONG, S. P. 2008. Meeting US biofuel goals with less land: the potential of Miscanthus. Global change biology, 14, 2000-2014.

[45] PŁAŻEK, A., DUBERT, F., KOŚCIELNIAK, J., TATRZAŃSKA, M., MACIEJEWSKI, M., GONDEK, K. & ŻUREK, G. 2014. Tolerance of Miscanthus× giganteus to salinity depends on initial weight of rhizomes as well as high accumulation of potassium and proline in leaves. Industrial Crops and Products, 52, 278-285.

Agronomic Feasibility Study[46] performed by CREA and Biochemtex together with FAO. It is drought resistant with sterile seeds and saline soil tolerant making it suitable for marginal soil conditions. It is considered as a cost-effective energy crop because it can be harvested annually for decades after planting.

Similarly, switchgrass (*Panicum virgatum L*.) is a perennial grass native to North America, has a wide range of climatic adaptability and can be propagated by seeds. It has a very well-developed rooting system as it can reach up to the depth of 10 feet making it adaptable to drought conditions and tolerant to severe water stress conditions. It grows up to 2.5m in height and can produce the maximum yield of 14 odt/ha/yr[47].

Project Timeline: Start 10/2011 - End: 09/2015

Success elements (targets achieved) and Failures (obstacles and challenges faced): *Work is ongoing*

Innovation: According to this report[48] which highlights the conclusive results from the OPTIMA project, the project led to some innovative systems of vegetative propagation for Giant reed and Miscanthus. Research and demonstration work on hydro-seeding of switchgrass also showed interesting results for the diffusion of the species in marginal lands and sustainable management of the crop.

According to the European Innovation Scoreboard 2017 report[49], Italy is considered as a moderate innovator. However, the case study region Sicilia ITG1 is the lowest performing region in innovation in comparison to other regions in Italy.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: University, Research Institutions

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[46] PULIGHE, G., BONATI, G., FABIANI, S., BARSALI, T., LUPIA, F., VANINO, S., NINO, P., ARCA, P. & ROGGERO, P. P. 2016. Assessment of the agronomic feasibility of bioenergy crop cultivation on marginal and polluted land: A GIS-based suitability study from the Sulcis area, Italy. Energies, 9, 895.
[47] https://articles.extension.org/pages/26635/switchgrass-panicum-virgatum -for-biofuel-production#Current_Potential_for_Use_as_a_Biofuel. Accessed on 6th Nov, 2018
[48] Monti, A., & Cosentino, S. L. (2015). Conclusive results of the european project OPTIMA: optimization of perennial grasses for biomass production in the Mediterranean area. *BioEnergy Research*, *8*(4), 1459-1460.
[49] Ibid.

Case 5: Poplar in Italy

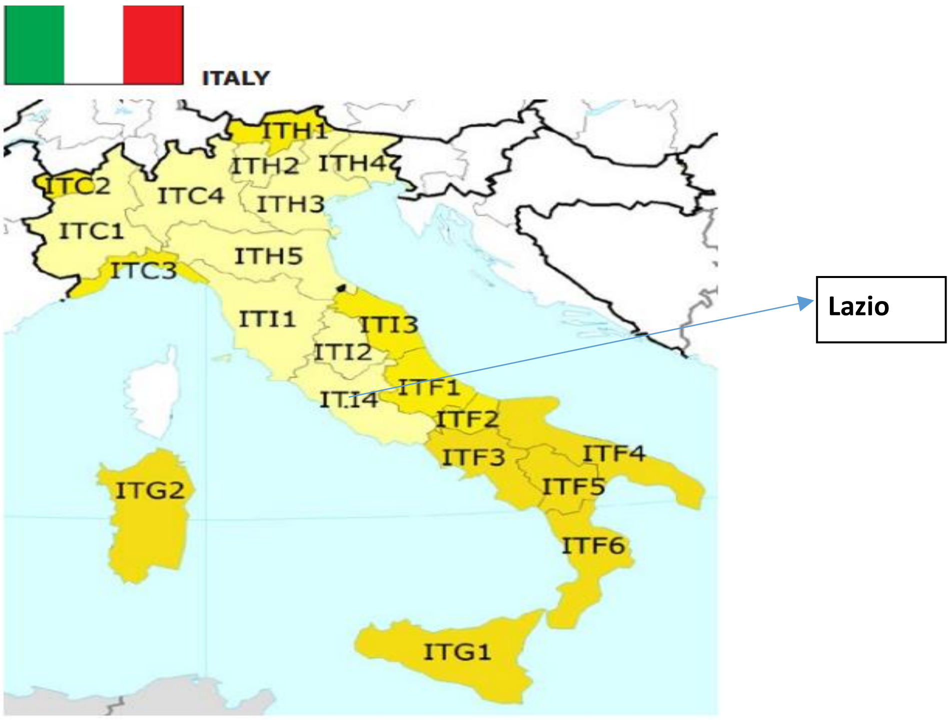
Region +NUTS code: Lazio Region ITI4

Demonstration/Implementation level: Regional

Size of the cultivated land: <50 Hectares

Climate: Mediterranean, continental (Zone 1 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: IBAF-CNR Institute of Agro-environment and Forest Biology -National Research Council



Italy NUTS2 map[50]

Introduction of the region and the Good Practice project:

The Sacco river valley, Province of Rome in Lazio region was affected by the agro-environmental contamination of hexachlorocyclohexane, an obsolete organochlorine pesticide (HCH isomers). The region has medium-high concentrations of HCH isomers. Among the three isomers, the region contains: αHCH: up to 0,02 mg/Kg; βHCH: up to 0,06 mg/Kg; γ-HCH: 0,02 mg/Kg. The legal limit for each isomer is 0,01 mg/Kg[51]. This was the result of the chemicals disposed from the manufacturing plants and industries from the region into the Sacco River and the subsequent use of the river water to irrigate the land or the runoff during flooding.

[50] Source: European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491 accessed on 19th October 2018
[51] IBAF-CNR Phyto-portfolio. Italy: Institute of Agro-environmental and Forest Biology

As a potential option of risk management associated with the contamination of food chain and its negative impact on animal and human health, poplar short rotation forestry (SRF) was chosen for phytoremediation of polluted sites. Based on the ARSIAL project[52] evaluations and a Life Cycle Assessment approach identifying the environmental burden of this management practise, it was found that the distance between the field of plantation and the industrial boiler centre where the wood chips were used played an important role in determining the environmental burden. Soil management, weed control fertilisation including transportation of fertilisers represented only 35.4% of the total CO2-eq release for the short distance (<10km) scenario. However, when looking at the whole production cycle of 11 years, the impact results increased. The Global Warming Potential (GWP) was 94.4% higher for wood chip harvested in small parcels with a mean distance of >10km. The EDIP (combined ozone depletion acidification and eutrophication) impact was found to be almost double for long distance transportation of wood chips. To reduce the environmental burden associated with long distance transportation, it was suggested that more industrial boiler centres could be established to cover the large contaminated areas and more efficient methods of cutting and chopping could be applied.

Industrial Crop: Poplar (*Populus spp.*) Lignocellulosic crop. Genotype: Monviso

Potential as an Industrial crop: Poplar is grown originally in Northern Europe but can also be grown in Southern and Central European regions. It is a perennial lignocellulosic crop similar to willow, but it is less frost resistant thus not widely cultivated in Northern Europe[53]. The yield of energy poplar is 8-15 t d.m./ha/year and hybrid poplar can give up to 16-20 t d.m./ha/year on good soils[54]. The lignocellulosic property of poplar makes it suitable for easier carbohydrates extraction from biomass. The selected poplar genotypes have improved yield, pest resistance and easy propagation characteristics. They have short harvesting cycles therefore unlike other bioenergy crops they do not need to be stored and can be harvested throughout the year. Hybrid Poplars are one of the fastest growing trees in the world[55]. The poplar plantation is 15-20 years and 5-7 harvest can be made in a 3-year cultivation cycle[56]. Poplar has high potential value chain with multiple end-use as it can supply biomass for solid biofuels, advanced biofuels, bio-based products (construction materials, packaging materials, paper, pulp, paints, …etc.). In addition to that Poplar has a rooting ability that makes it suitable for rhizoremediation, which is a kind of phytoremediation comprised of a complex rooting system. Poplar also has established itself as a successful

[52] DANIELI, P., PRIMI, R. & RONCHI, B. 2013. Impact of growing short rotation poplar forest: the case study of the Sacco river valley, Lazio Region, Italy, ibid.
[53] GELETUKHA, G., ZHELIEZNA, T. & TRYBOI, O. 2014. Prospects for the growing and use of energy crops in Ukraine. UABio Position Paper, 30.
[54] Ibid.
[55] SANNIGRAHI, P., RAGAUSKAS, A. J. & TUSKAN, G. A. 2010. Poplar as a feedstock for biofuels: a review of compositional characteristics. Biofuels, Bioproducts and Biorefining, 4, 209-226.
[56] GELETUKHA, G., ZHELIEZNA, T. & TRYBOI, O. 2014. Prospects for the growing and use of energy crops in Ukraine. UABio Position Paper, 30.

species for phytoremediation in a field trial done in Italy[57]. Results from the field trial have shown potential that growing poplars on their contaminated soils is beneficial to farmers as it results in sustainable recovery of soils, making them suitable for food-agricultural activities. Sulcis area in Sardinia, Italy also used Arundo donax (giant reed) to ameliorate the abandoned land contaminated due to industrial disposal[58].

In addition, during the process the biomass produced can be used as feedstock for bioenergy and bioproducts[59]. Bioenergy potential calculations revealed that poplar can potentially yield up to 22 PJ (HHV) of yearly primary energy that can be used for heat, conversion to transportation fuels, and/or electricity production[60]. Poplar is being researched and studied not only in Europe but across the globe in China, USA, and Canada. In the Upper Mississippi River Basin, USA, 60% of the land is marginal and suitable for hybrid Poplar[61]. One of the studies in China has found that subcritical hydrothermal liquefaction of poplar performed at 220-280°C leads to production of light oil which on further extraction with acetone produced heavy oil. This bio-oil is found to have good antioxidant activity and can be used as additive in bio-diesel to improve oxidation stability[62].

Marginality factor: One of the main marginality factor for Lazio region is the soil contamination. Each region has its key assets which characterise it. These key assets are grouped in biophysical, economic, environmental and social categories. The case from Lazio region has its own characteristics based on these key assets and the marginality factors and their marginality level as shown below.

[57] BIANCONI, D., DE PAOLIS, M., AGNELLO, A., LIPPI, D., PIETRINI, F., ZACCHINI, M., POLCARO, C., DONATI, E., PARIS, P. & SPINA, S. 2011. Field-scale rhyzoremediation of a contaminated soil with hexachlorocyclohexane (HCH) isomers: the potential of poplars for environmental restoration and economical sustainability. Handbook of Phytoremediation. Eds. IA Golubev. Nova Science Publishers, New York, 783-794.

[58] https://en.forbio-project.eu/assets/content/publication/GSOP_18_CREA_final.pdf accessed on 18th October, 2018.

[59] AGHAALIKHANI, A., SAVUTO, E., DI CARLO, A. & BORELLO, D. 2017. Poplar from phytoremediation as a renewable energy source: gasification properties and pollution analysis. Energy Procedia, 142, 924-931.

[60] SAHA, M. & ECKELMAN, M. J. 2018. Geospatial assessment of regional scale bioenergy production potential on marginal and degraded land. Resources, Conservation and Recycling, 128, 90-97.

[61] FENG, Q., CHAUBEY, I., ENGEL, B., CIBIN, R., SUDHEER, K. & VOLENEC, J. 2017. Marginal land suitability for switchgrass, Miscanthus and hybrid poplar in the Upper Mississippi River Basin (UMRB). Environmental Modelling & Software, 93, 356-365.

[62] WU, X.-F., ZHOU, Q., LI, M.-F., LI, S.-X., BIAN, J. & PENG, F. 2018. Conversion of poplar into bio-oil via subcritical hydrothermal liquefaction: structure and antioxidant capacity. Bioresource technology.

			Marginality level		
Key Assets	Criterias	Indicators	High	Medium	Low
Bio-physical	Soil	Soil contamination	x		
Economic	Competitive crops for bio-based markets	Increasing standardisation and certification of new bio-based products	x		
		Increasing support for innovation activities		x	
	Profitability	Growing Trade/Business prospect for biomass mobilization			x
Environmental	Resource Use	Land use	X		
		Water use efficiency		x	
		Conservation of Biodiversity			x
Social and Institutional	Socio-economic Infrastructure	Contribution to local economy	x		
		Creation of new jobs		x	
		Socio-economic Infrastructure			x

Project Timeline: Project 1 (Start: 04/08 - End: 04/09) and Project 2 (Start: 05/13 - End: 12/13)

Funding sources: Supported by National Public Fund. Project 1: €38,100 and Project 2: €12,300.

According to the JRC report ‘Research and Innovation Observatory (RIO) Country Report[63] Italy 2017, budget cuts in public funding are affecting research and innovation activities. In addition to that business research and innovation activities in Italy are far below the EU average. Small-scale and new innovative companies are suffering due to strict lending conditions. According to the JRC report Italy requires harmonised national and regional strategies for it to be effective during the implementation process. Their public-private partnerships need some synergy to drive research and innovation forward.

Success elements (targets achieved) and Failures (obstacles and challenges faced): At the demonstration level (field trial level) poplar has proven to be a Good Practice example to grow in contaminated lands with poor soil conditions such as soil acidity and salinity through its capacities of phytoremediation.

In the ARSIAL project, one of the obstacles was the long distance between the poplar plantation sites where the land needs the phytoremediation and the industrial boilers sites where the wood chips are stocked and utilised. In this case, the longer the distance, the higher the environmental burden was when using these poplar wood chips.

One of the case studies done in Germany[64] shows that farmers hesitate to establish plantations of SRC, mainly because of its low potential for economic profitability. Biomass yields on marginal land are below 7–8 Mgdm y^{-1} ha^{-1} which means the average results for the cultiva-

[63] NASCIA, L., PIANTA, M. & LA PLACA, G. 2018. RIO Country Report 2017: Italy. JRC, Luxembourg: European Commission.
[64] SCHWEIER, J. & BECKER, G. 2013. Economics of poplar short rotation coppice plantations on marginal land in Germany. Biomass and bioenergy, 59, 494-502.

tion of poplar (SRC) on marginal land is lower than the CAP subsidy payments granted to farmers by the EU which is around €300 ha^{-1}.

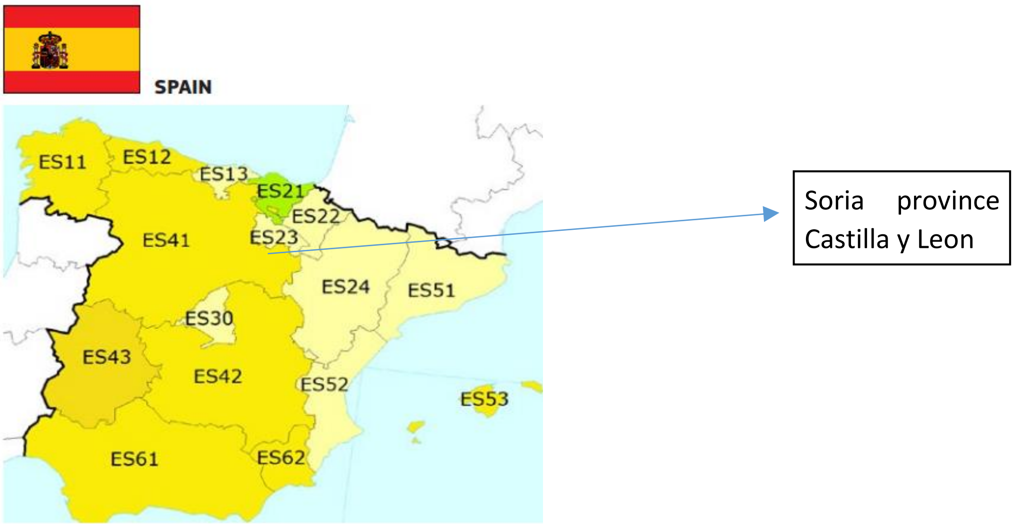
Innovation: This case study contributes the innovation at the technological level. According to the European Innovation Scoreboard 2018 report[65], the Lazio region of Italy is considered as a moderate innovator when analysed in a holistic manner analysing its innovation performances in technological, service, commercial, managerial, public sector and social systems. In comparison to the previous year the innovation performance of the ITI4 has decreased by almost 3%.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Research Institutions/Universities

[65] EC, E. C. 2018. European Innovation Scoreboard 2017: Country Profiles [Online]. Available: https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en [Accessed 10th October 2018].

Case 6: Rye and Tall wheatgrass in Spain

Region +NUTS code: Soria province, Castilla y León region, Central-Northern Spain/ NUTS code ES41



Spain NUTS2 map[66]

Demonstration/Implementation level: Regional level

Size of the cultivated land: farm of 300 ha with arable land of which 40 ha is marginal

Climate: Mediterranean (Zone 1 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: CEIMAT

Introduction of the region and the 'Good Practice' project: The Soria Province in the Castilla y Leon Region is in Northern-central Spain and has continental Mediterranean climatic conditions with low precipitation levels, cold winters and short summers. The study was performed between 2014 and 2015. The region is representative of a rain-fed production system. The marginal land in the demonstration site was characterised by poor sandy soil which is 76% sand, 20% lime and 4% clay with 0.54% organic matter and with pH 7.2 making its soil conditions neutral. The sandy soil led to good drainage which meant low water and nutrient retention and loss of nutrients by leaching. The soil overall had low productivity and salinity problems.

Industrial Crops: Rye and Tall wheatgrass (*Thinopyrum ponticum*)

Potential as an Industrial crop: Rye and Tall wheatgrass were picked for demonstration in the marginal sites of the Castilla y Leon Region. Rye has been a traditional cereal crop grown in Europe and known to have high rusticity and better adaptation to colder climatic conditions compared to tall wheatgrass. Tall wheat grass is native to Eurasia and was later introduced to other regions of the world. It has proven to be a new low-cost alternative for

[66] Source: European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491 accessed on 19th October 2018

farmers allowing them to meet CAP requirements in Spain[67]. In addition, Tall wheatgrass has shown higher biomass productivities compared to other species tested in rain-fed conditions in Spain[68]. Tall wheatgrass is a good species to grow in saline soils as it reduces salinity. When crossed with wheat, some of the species become stress tolerant and pest resistant.

Marginality Factors:

For the Soria Province one of the main biophysical marginality factors are the poor sandy and saline soil and low water availability. Each region has its key assets which characterise it. These key assets are grouped in biophysical, economic, environmental and social categories. The case from Soria region has its own characteristics based on these key assets and the marginality factors and their marginality level as shown in table below.

[67] Ciria, C. S. et al, 2016. Strategies for marginal lands management in rain fed agricultural farm in Spain: economic and energy analyses. Paper presented at 24th European Biomass Conference and Exhibition. 6-9June, 2016, Amsterdam, The Netherlands.

[68] Maletta, E. et al .2014. Evaluation of five summer dormant grasses as potential energy crops for rain-fed lands in Spain. Paper presented at the 20th European Biomass Conference and Exhibition, 18-22 June, 2-012 Milan, Italy.

			Marginality level		
Key Assets	Criteria	Indicators	High	Medium	Low
Bio-physical	Soil	Limitation in rooting			x
		Adverse chemical composition			x
		Low Fertility	x		
	Climate and soil	Excessive wetness			x
	Terrain	Adverse terrain		x	
	Climate	Adverse Climate		x	
	Productivity	Crop Yields	x		
	Funding	Private funds/Public funds		x	
	Rent	Land rent	x		
	Accessibility	Infrastruture		x	
Environmental	Resource Use	Conservation of Biodiversity			x
		Land use		x	
	Water	Water availability	x		
		Water use efficiency	x		
	Soil	Soil erosion	x		
		Soil organic and nutrient content	x		
		GHG emission related to iLUC			x
		GHG reduction			x
Social and Institutional	Socio-economic Infrastructure	Increasing research and development activities	x		x
		Creation of new jobs	x		x
		Increasing support for human capital development (training and skills in new technology)	x		x
	Accessibility	Remoteness and rurality	x		
		Allocation and secure tenure of land	x		
	Policy	Presence of policy instrument (Effectiveness of policy)	x		
		Consistency of policy	x		
		Monitoring procedures	x		
	Population demography	Population, age density and institutional capacity	x		
	Cultural	Lack interest and mistrust about prospects of marginal lands		x	
	Awareness	Knowledge on availability and prospects of marginal lands	x		

Project Timeline: Start: 2012 - End: 2015

Funding source: € 258,670 is the total funding for the project (this also including budget for other activities) - Supported by the National Project Program INNPACTO.

New strategies for the integral utilisation of lignocellulosic biomass for the sustainable production of hydrogen with minimised CO_2 emissions **(**BioH2).

Success and Failures: The demonstration of tall wheatgrass in the marginal lands area has shown the highest farm production with gross margin of 134-138 €/ha which is about a 12% increment in the gross farm production on marginal lands. Rye increased the gross margin of farm production by 4.5%. Similarly, tall wheatgrass has shown positive results increasing energy production and energy efficiency of the farm production system.

However, there are no established markets for farmers to sell their produced biomass. Thus, the price/cost of biomass is estimated and there is limited understanding of actual price.

Innovation: The case study contributes to introduce new crop alternatives in marginal agricultural lands thus producing opportunities for farmers.

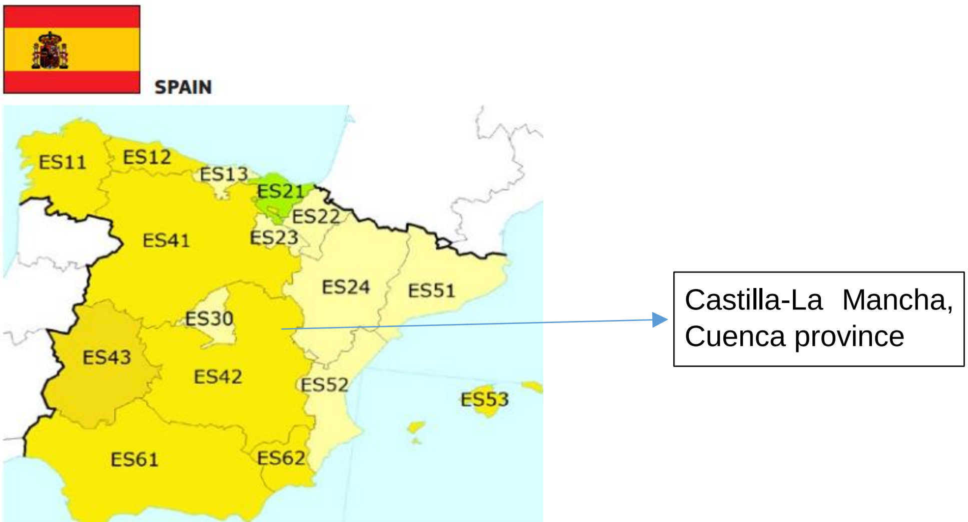
According to the European Innovation Scoreboard 2018[69], Spain is a Moderate Innovator on a countrywide level. The Castilla y León ES41 region is also a moderate innovator, however in comparison to the previous year the region's innovation performance has decreased by 6.6%.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Farmer associations (ASAJA, COAG, UPA, UCCL), Farmer cooperatives (COPISO, URCACYL), Farmers credit banks (CAJA RURAL) and Research Institutions (CIEMAT, ITACYL)

[69] ibid.

Case 7: Lavender in Spain

Region + NUTS code: Region: Castilla-La Mancha, Cuenca province, NUTS 3 code for provinces: ES423



Spain NUTS2 map[70]

Demonstration/Implementation level: Local/Regional

Size of the cultivated land: 3 hectares

Climate: Mediterranean (Zone 1 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: ALCAMANCHA S. Co-op

Introduction of the region and the 'Good Practice' project: the ALCAMANCHA co-operative has recently started (February 2018) to cultivate *Lavandula hybrida* in 3 hectares of the municipality of Campos del Paraíso, where it has found low yields mainly due to the low fertility of the soil. Campos del Paraíso is located in the central area of Spain, in the Region of Castilla-La Mancha and the Province of Cuenca.

Taking advantage of the experience from the COCOPE co-operative, where this crop has been cultivated with success in the past 18 years over 300 hectares (nowadays the cultivation of this crop has stopped due the low interest of their farmers), ALCAMANCHA has started cultivating 3 hectares and plans to expand this crop in a very short time over 3 more hectares.

Industrial Crops: Lavender **(***Lavandula hybrida)*

Potential as an Industrial crop: Lavender has potential use as an essential oil for the cosmetics and perfume industries. Essential oil quality is very subjective to water stress conditions.

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[70] Source: European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491 accessed on 19th October 2018

Lavender oil has the property of hydrosols with antibacterial property and can be used in the agro-food industry to improve safety and shelf-life[71].

Marginality Factors: The main biophysical marginality factor in the municipality of Campos del Paraíso is the soil, with very low fertility and a sandy structure. Low fertility implies marginality based in another economic asset, the low productivity yields. Each region has its key assets which characterise it. These key assets are grouped in biophysical, economic, environmental and social categories. The case from Campos del Paraíso region has its own characteristics based on these key assets and the marginality factors and their marginality level as shown below.

			Marginality level		
Key Assets	Criteria	Indicators	High	Medium	Low
Bio-physical	Soil	Low fertility			x
Economic	Productivity	Yield			x
Environmental	Soil Quality	Organic content and nutrient balance			x

Project Timeline: Start: February 2018 - End: Unknown.

Funding source: none (self-funded)

Success elements (targets achieved) and Failures (obstacles and challenges faced):

Though the co-operative has managed to cultivate with success *Lavandula hybrida* in marginal lands, it will take time until it gets its first harvest (two years from planting). Currently, market price is very profitable, a principal reason for why the cooperative wishes to continue expanding production of this crop.

In spite of this, taking advantage of the experience from COCOPE, the ALCAMANCHA co-operative is aware of the fact that although the prices have maintained a general profitability during the last decade, there have been some bad years where the prices provoked problems with the land rent.

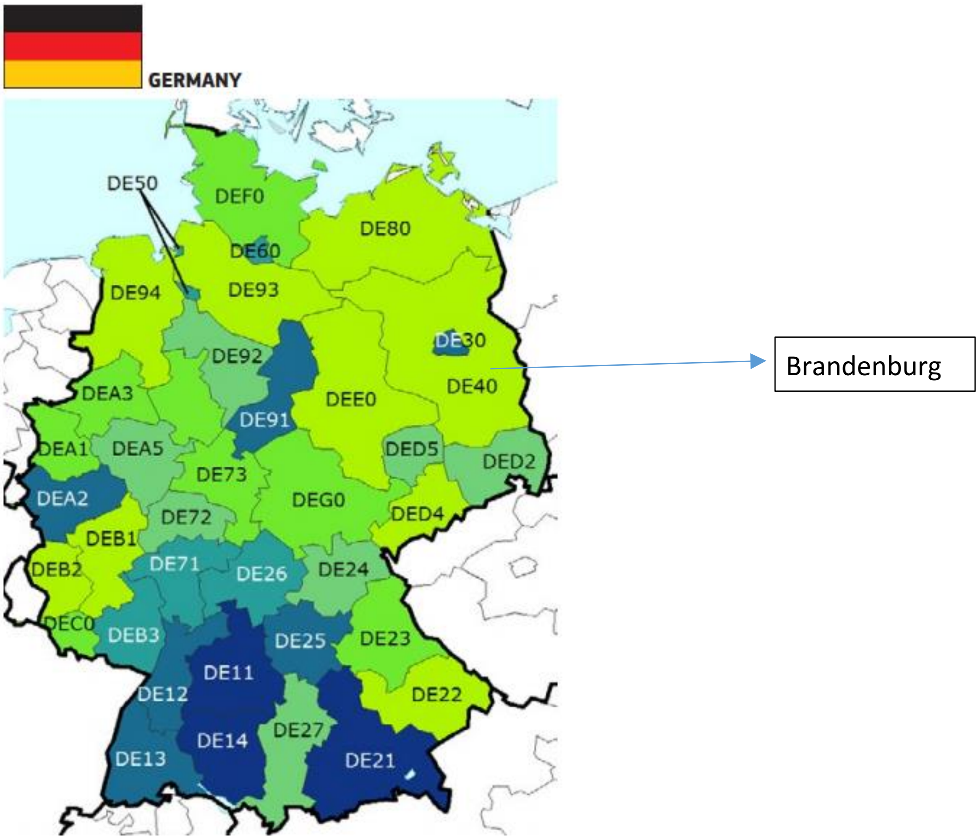
Innovation: *Work is ongoing*

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Farmers, Co-operatives and Seed producers

[71] D'Amato, S., Serio, A., López, C. C., & Paparella, A. (2018). Hydrosols: Biological activity and potential as antimicrobials for food applications. *Food Control*, *86*, 126-137.

Case 8: Short Rotation species in Germany

Region +NUTS code: Lusatia, Brandenburg Region NUTS code: DE40



Germany NUTS2 map[72]

Demonstration/Implementation level: Regional

Size of the cultivated land: 50-100 Hectares

Climate: Continental & Boreal (Zone 3 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: Brandenburg University of Technology (BTU)

Introduction of the region and the 'Good Practice' project: The region is characterised by a sub-continentally influenced humid climate of the temperate zone and soil is characterised by a post-mining landscape. The land is currently also used as lignite mine. This region also has abandoned post-industrial sites with anthropogenic substrates. The project site is a former railway site in Cottbus and has the presence of coarse fragments such as stones and boulders on the soil surface as well as within the soil. There are marginal soil conditions both in post-mining sites as well as abandoned industrial sites in the region.

[72] Source: European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491 accessed on 22nd October 2018

According to the SEEMLA report[73] about 6.8% of the total arable land in Germany (118 690 km^2) is considered to have very low yield potentials. 30% of the agricultural land in the state of Brandenburg, representing an area 4000 km^2, has poor soil qualities and yields considered as economically marginal[74].

Industrial Crops: Short rotation crops (fast growing woody crops/trees)

Potential as an Industrial crop:

Poplar *(Populus x spec)* is a fast-growing pioneer tree species native to temperate climate zones, used for energy, fuelwood in short-rotation coppices and material. Its soil requirements are under demanding although it requires a moderate soil pH. It can be used to clean contaminated, abandoned land, conserve soil by intensive rooting, humus accumulation and minimal nutrient removal. It has a low tolerance to heavy metals and may exhibit irreversible vitality loss during strong summer droughts. For short-rotation coppicing, when fully mechanised, dry matter content of wood chips is 30%[75].

Black locust (*Robinia acacia)* is a fast-growing pioneer tree species which can produce high-quality timber, multipurpose energy and can be used as a forage crop. It has been naturalised in the Brandenburg region for 300 years. It can grow on a wide variety of soils: although it is sensitive to topsoil compaction and waterlogging, it has high heavy metal and acid tolerance. It can assimilate atmospheric nitrogen into the soil, prevent water formation and leaching of contaminants and promotes soil humus accumulation. Other growth limiting factors include sensitivity to late frost and requirement of adequate phosphorous and potassium supply.

Marginality factor: The main biophysical marginality factor in the Brandenburg region is adverse rooting and low soil fertility. Each region has its key assets which characterise it. These key assets are grouped in biophysical, economic, environmental and social categories. The case from Lusatia has its own characteristics based on these key assets and the marginality factors and their marginality level as shown in table below.

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[73] HANZHENKO, O. 2016. SEEMLA: Catalogue for bioenergy crops and their suitability in the categories of Marginal lands [Online]. Available: http://seemla.eu/en/2016/09/30/catalogue-for-bioenergy-crops-and-their-suitability-in-the-categories-of-magls/ [Accessed 2018].

[74] Statistisches Bundesamt (2016). Facts and Figures online: Land use [URL: https://www.destatis.de/EN/FactsFigures/EconomicSectors/AgricultureForestryFisheries/LandUse/Tables/Areas.html

[75] MERGNER, R., JANSSEN, R., RUTZ, D., KNOCHE, D. & KÖHLER, R. 2017. Techno-economic feasibility of the case study in Germany: FORBIO fostering sustainable feedstock production for advanced biofuels on underutilised land in Europe [Online]. Available: https://forbio-project.eu/assets/content/publication/Technoeconomic_feasibility_FORBIO_Germany_12.04.2018.pdf [Accessed 24th October 2018].

			Marginality level		
Key Assets	Criteria	Indicators	High	Medium	Low
Bio-physical	Soil	Limitation in rooting		x	
		Low Fertility	x		
Economic	Productivity	Production Costs		x	
		Yield	x		
Environmental	Soil quality	Organic content and nutrient balance	x		
Social and Institutional	Socio-economic	Contribution to local economy	x		

Based on the information collected from the survey, the Lusatia Region can be assessed as having medium to high marginality in all categories. In terms of its bio-physical factors, its soil displays medium marginality in terms of rooting limitation and high marginality due to low soil fertility. When assessed economically, the region is highly marginal in terms of crop yield productivity and moderately marginal due to production costs. For environmental factors, there is high marginality in the domain of soil organic content and soil nutrient balance. Finally, when assessed for social and institutional factors, the region is highly marginal when it comes to its contribution to the local economy.

Project Timeline: Start: 2005 and ongoing

Funding source: Supported by private company

According to the JRC report[76] 'Research and Innovation Observatory (RIO) Country Report Germany 2017', the number of entrepreneurs in Germany continues to decline, partly due to rising opportunities within established firms given the strong labour market. Innovation activity has equally become concentrated in large firms, as well as medium-high tech manufacturing sectors. However, since this is the case especially for automotive production, the potential for market intake of alternative fuels is still attractive. There is additional potential for innovation through the joint initiatives the Excellence Strategy and the Programme for the Support of Young Scientists, however these require strategic decision-making.

Success elements (targets achieved) and Failures (obstacles and challenges faced): One case study done in Germany[77] shows that farmers hesitate to establish plantations of SRC, mainly because of its low potential of economic profitability. Biomass yields on marginal land is below 7–8 Mgdm y^{-1} ha^{-1} which means the average results for the cultivation of poplar (SRC) on marginal land is lower than the CAP subsidy payments granted to farmers by the EU which is around €300 ha^{-1}.

Planting black locust (*Robinia pseudoacacia L.*) on severely disturbed post-mining areas despite low soil fertility can produce high biomass yield with the creation of beneficial land-use system. To reduce nutrient exports from short rotation coppice, a better selection of species and clones with a high nutrient use efficiency can be recommended, such as the use of N-

[76] WOLFGANG SOFKA, EDLIRA SHEHU & HRISTOV, H. 2018. RIO Country Report 2017: Germany [Online]. JRC, Luxembourg: European Commission. Available: https://rio.jrc.ec.europa.eu/en/country-analysis/Germany/country-report [Accessed 24th October 2018].

[77] JANINE SCHWEIER & GERO BECKER 2013. Economics of poplar short rotation coppice plantations on marginal land in Germany. Biomass and bioenergy, 59, 494-502.

fixing species i.e. black locust (especially for N poor sites), as well as an increase in the rotation period.

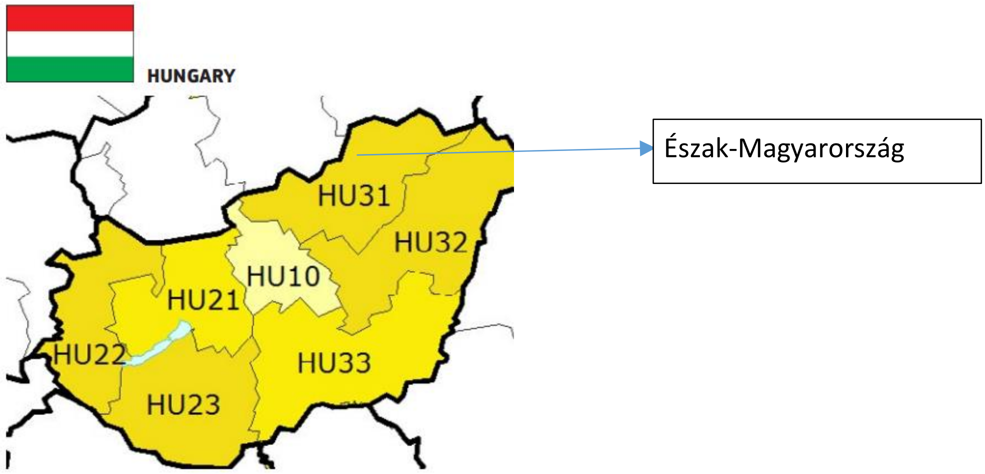
Innovation: This case study contributes to innovation at the technological level. According to the European Innovation Scoreboard 2018[78] report Germany is considered as a strong innovator when analysed in holistic manner analysing their innovation performances in technological, service, commercial, managerial, public sector and social systems.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Research Institutions and University

[78] EC, E. C. 2018. European Innovation Scoreboard 2018: Country Profiles [Online]. Available: https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en [Accessed 10th October 2018].

Case 9: Energy crops in Hungary

Region +NUTS code: Middle- Tisza**,** Borsod-Abauj-Zemplen county (NUTS 3) falls under Észak-Magyarország region. NUTS2 HU31



Hungary NUTS2 map[79]

Demonstration/Implementation level: Regional

Size of the cultivated land: <50 Hectares

Climate: Continental & Boreal (Zone 3 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: WWF Hungary

Introduction of the region and the 'Good Practice' project: One Europe More Nature - (OEMIN) is the project implemented by WWF Hungary. Renewable energy sources currently represent only 4.9% of Hungary's primary energy consumption, the most important being bi-omass, accounting for nearly 90% of all renewable energies[80]. Hungary had altogether 182 power plants with a total capacity of 8836 MW in the year 2008, with capacity of renewables increasing and co-firing coal and biomass to a certain percentage[81]. The Tisza River Basin is one of the largest in Europe and yet natural habitats have disappeared to a large extent; there are only a few natural floodplain forests, floodplain grasslands and wetlands remaining

[79] Source: European Innovation Scoreboard Report 2017. http://ec.europa.eu/DocsRoom/documents/31491 accessed on 22nd October 2018

[80] DEÁK, Z. & FERENCZ, A. 2017. Financial feasibility of short rotation energy crops in Hungary-a case study. Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu, 19.

[81] DIBÁCZI, Z., HUJBER, D., LIPCSIK, M. & SIMON, T. 2010. Study on biomass trade in Hungary. Energy Cen-tre-Energy Efficiency, Environment and Energy Information. Agency Non-profit Limited Company (Hungary) http://www. 4biomass. eu/document/file/Hungary_final2. pdf. Data dostępu, 15.

and many of the original floodplains landscape were fragmented and habitats cut by dams due to the river control[82].

The aim of the WWF is to enhance the conservation status of floodplain habitats, both forests and grassland, by implementing an environmentally, economic and socio-economic-attractive plan: harvesting invasive black locust biomass for renewable energy purposes[83]. This was done in collaboration with the energy company AES Hungary. Additionally, the least fertile and valuable abandoned arable lands were converted into energy tree plantations of native species (*Salix viminalis, Salix express*) to restore the land.

Industrial Crops: Native energy crops/trees plantation.

Potential as an Industrial crop:

Black locust (*Robinia pseudoacacia*, a.k.a. acacia) is a promising species for energy tree plantations although other tree species such as *Populus, Salix* species and *Ulmus pumilla* can also be suitable[84]. In the 1960s, Hungary had more black locust forests than all the other European countries, two thirds of which were used for coppice. It has multi-industrial (mining, construction, furniture) agricultural (post and pole wood) and energy uses. The species presents a very high density (690 kg/m^3), as well as a fast height growth rate (2–6 cm/day) which places it among the most fast-growing plants. It can grow up to 15-30 meters and develop a crown of 20-40 centimetres in diameter, its moisture content ranges around 40-45% making it readily utilisable and its favourable flammable properties make it possible for larger power plants[85]. It also can fix atmospheric nitrogen and requires little or no nitrogen fertilization. Its low moisture content enables reduced handling costs and enhances desirability for efficient energy conversion[86]. Additionally, black locust trees are the main basis for Hungarian apiculture and honey production[87].

Harvesting of black locust trees grown for energy purposes, given its high density and hardness, currently does not have a mature technology and machines become depreciated significantly for trees older than 3 years[88]. Junior plantations do not bring about economical yields as tons of chips harvested per hectare do not cover the combined cost of harvesting, storage, supplies, loading and transportation. Technological progress in harvesting or feeding not only for electricity but also directly generated heat into the consumer grid would considerably increase the efficiency of energy utilisation and decrease production costs.

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[82] BÖSZE, S. & MEYER, H. 2014. Regional development opportunities of protected areas and natural assets in the Carpathians. Work Package, 4.

[83] WWF. 2005. One Europe, More Nature in the Tisza River Basin, Hungary [Online]. Available: http://www.wwf.eu/?53721/One-Europe-More-Nature-in-the-Tisza-River-Basin-Hungary [Accessed 24th October 2018].

[84] RÉDEI, K., VEPERDI, I., TOMÉ, M. & SOARES, P. 2010. Black locust (Robinia pseudoacacia L.) short-rotation energy crops in Hungary: a review. Silva Lusitana, 217-223.

[85] DEÁK, Z. & FERENCZ, A. 2017. Financial feasibility of short rotation energy crops in Hungary-a case study. Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu, 19.

[86] RÉDEI, K., VEPERDI, I., TOMÉ, M. & SOARES, P. 2010. Black locust (Robinia pseudoacacia L.) short-rotation energy crops in Hungary: a review. Silva Lusitana, 217-223.

[87] DEÁK, Z. & FERENCZ, A. 2017. Financial feasibility of short rotation energy crops in Hungary-a case study. Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu, 19.

[88] Ibid.

Rising market competition between SRC products and bio-methane, bio-hydrogen, or introducing waste puts further pressure on the development of black locust SRC.

Marginality factor: Each region has its own key assets which characterise it. These key assets are grouped into bio-physical, economic, environmental and social categories. The key assets of the Middle-Tisza Region in Hungary and the marginality factors that describe the region and its marginality level are shown in table below.

			Marginality level		
Key Assets	Criteria	Indicators	High	Medium	Low
Bio-physical	Climate and Soil	Excessive wetness			x
	Terrain	Adverse terrain	x		
	Climate	Adverse Climate		x	
Economic	Profitability	Revenues for farmers from unused land		x	
	Diversification of farmers incomes	Diversification of rural enterprises (Industrial supply security and energy security)	x		
		Diversification of farmers income (Flexibility and controllability)			x
Environmental	Resource use	Land use			x
		Conservation of Biodiversity	x		
	Water	Water availability		x	
Social and Institutional	Accessibility	Remoteness and rurality	x		
	Socio-economic	Contribution to local economy		x	
	Awareness	Knowledge on availability and prospects of marginal lands			x

Based on the information collected from the survey, the Middle-Tisza Region can be assessed as having varying marginality in each respective category. In terms of biophysical factors, excessive wetness from climate and soil does not affect marginality of land, however adverse climate creates medium marginality while adverse terrain creates high marginality for the region. When assessed from the economic perspective, diversification of industrial supply and energy security does not make the Middle-Tisza Region marginal, however it becomes highly marginal due to the diversification in the flexibility and controllability of farmers' income. Finally, profitability from revenues for farmers operating on unused land makes the region moderately marginal. When assessed from an environmental perspective, biodiversity conversation and management pose a severe issue of marginality for the region. In contrast, land use does not increase its marginality. For water availability, there is a medium marginality factor. When assessed based on social-economic infrastructure, remoteness and rurality are prominent marginality factors. The region remains marginal in terms of its contribution to the local economy, however social awareness surrounding the land and its prospects offer promising changes.

Project Timeline: Start: 12/2007 - End: 12/2017

Funding source: €120,000 - Supported by a corporate fund

According to the JRC report[89] 'Research and Innovation Observatory (RIO) Country Report Hungary 2017', small domestic firms lack their own funding for R&D and must often wait for public support in order to launch innovative projects. Programmes supporting the cooperation between science, higher education and business suffer from having a short life-span. There is a lack of demand from the policy side for innovation, thus Hungary has little experience in pre-commercial public procurement. Additionally, a significant gap is opening between the supply and demand for qualified science and engineering personnel due to low rates of students graduating from those fields.

Success elements (targets achieved) and Failures (obstacles and challenges faced): *Work is ongoing*

Innovation: This case study contributes to innovation at the technological level. According to the European Innovation Scoreboard 2018 report[90], Hungary is considered as a moderate innovator. When analysed in holistic manner analysing their innovation performances in technological, service, commercial, managerial, public sector and social systems, the innovation performance for the region HU31 has decreased.

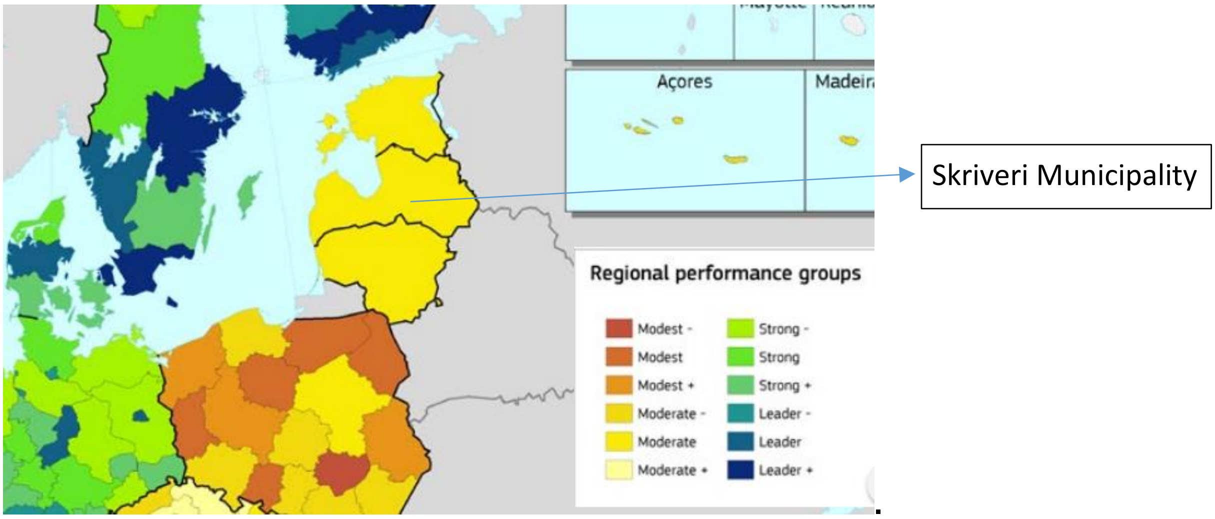
Stakeholders Involvement in the demonstration and implementation of the Good Practices: Local municipality and businesses were directly involved in the project.

[89] DŐRY, T., CSONKA, L. & SLAVCHEVA, M. 2018. RIO Country Report 2017: Hungary [Online]. JRC, Luzembourg: European Commission. Available: https://rio.jrc.ec.europa.eu/en/country-analysis/Hungary/country-report [Accessed 24th October 2018].

[90] EC, E. C. 2018. European Innovation Scoreboard 2017: Country Profiles [Online]. Available: https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en [Accessed 10th October 2018].

Case 10: Reed canary grass and Festulolium in Latvia

Region +NUTS code: Skriveri, Central Latvia



Demonstration/Implementation level: Local

Size of the cultivated land: 16 Hectares

Climate: Continental and Boreal (Zone 3 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: Latvia State Forest Research Institute, SILAVA & Research Institute of Agronomy (Agency of Latvia University of Life Sciences and Technologies)

Introduction of the region and the 'Good Practice' project:

The study site for this agroforestry system was established in 2011 and demonstration trials were conducted for 2012 and 2013. The plantation was established on drained mineral soil. The soil texture was dominantly loam and sandy loam. Meteorological conditions were different for each trial year. The year 2012 had rich precipitation whereas in 2013 it was slightly lower in long term average. In year 2013, hot and dry periods were interrupted by short and heavy rainfall and lack of moisture in July and August had negative impacts on development of plants. In 2018, the poplar clone Vesten and commercial willow local breeds Monika and Visvaldis were planted in an agroforestry system by replanting dried maples.

Industrial Crops: Two perennial grass (Reed canary grass and Festulolium) and two legumes (Fodder galega and Lupine) were sown between the tree rows (*Populus sp., Prunus avium, Tilia cordata, Acer platanoides)* as conventional monocrops for seed production.

Potential as an Industrial crop: Reed canary grass, festulolium, galega are well known species in Baltic countries as long-persisting, productive grasses and legumes suitable for biogas or solid biofuel production (Cited in Rancane, S. et al., 2014)[91] and lupine has a highly developed root system, making it suitable to grow in sandy soil and is well adapted to low fertilisation input (Cited in Rancane, S. et al., 2014)[92]. This demonstration and economic evaluation of the agroforestry system with legumes and long-persisting perennial grasses has shown that the production cost decreases and biomass production and seed yield increases.

The agroforestry system has given an opportunity to increase the value of the total production through marketing multiple products from given limited spatial and soil resources (Feldhake et al., 2018)[93]. The system fosters plant species with lower level of competition for nutrients and moisture, thus ensuring the stable annual increase in biomass production (Bradule et al., 2013)[94] and making it a secure source of industrial biomass uses.

Marginality Factors:

For the region, one of the main biophysical marginality factor is a soil texture of heavy clay and stones and inconsistent soil moisture throughout the year. Stones cause mechanical issues for machinery and make it difficult to use the area as arable land. Researchers of the Institute of Agronomy are specialised in grass breeding. The area can be evaluated as an example of medium marginality level, with problems associated to the mechanisation of operations and a marginality characterisation of medium for soil fertility.

In addition to this, other biophysical, economic, environmental and social marginality factors which apply to the project region and are addressed in the table below with marginality levels from high, medium and low.

91 (Tilvikiene et al., 2010; Adamovics et al., 2011) Tilvikiene, V., Kadžiuliene, Z. & Dabkeviþius, Z. 2010. The evaluation of tall fescue, cocksfoot and reed canary grass as energy crops for biogas production. Grassland Science in Europe 15, 304–306. Adamovics, A., Dubrovskis, V., Plume, I. & Adamovica, O. 2011. Biogas production from Galega orientalis Lam. and galega-grass biomass. Grassland Science in Europe 16, 416– 418.

92 (Dubrovskis et al., 2011) Dubrovskis, V., Adamovics, A., Plume, I., Kotelenecs, V. & Zabarovskis, E. 2011. Biogas production from greater burdock, largeleaf lupin and sosnovsky cow parsnip. Research for Rural Development 17, 388–392.

93 Feldhake, C.M., Belesky, D.P. & Mathias, E.L. 2008. Forage Production Under and Adjacent to Robinia pseudoacacia in Central Appalachia, West Virginia. Advances in Agroforestry 4, 55–66

94 Bardule, A., Rancane, S., Gutmane, I., Berzins, P., Stesele, V., Lazdina, D. & Bāłrdulis, A. 2013. The effect of fertiliser type on hybrid aspen increment and seed yield of perennial grass cultivated in the agroforestry system. Agronomy Research 11, 13–25.

			Marginality level		
Key Assets	Criterias	Indicators	High	Medium	Low
Bio-physical	Soil	Limitation in rooting	x	x	
		Low Fertility		x	
		Adverse chemical composition		x	
	Climate and soil	Excessive wetness	x		
	Terrain	Adverse terrain	x		
	Climate	Adverse Climate			x
Economic	Productivity	Crop Yield			x
	Funding	Private funds/public funds			x
	Accessibility	Infrastructure		x	
	Land rent	(Revenue made each year within a project time)		x	
Environmental	Resource Use	Conservation of Biodiversity			x
		Land use		x	
	Water	Water availability	x		
		Water use efficiency	x		
	Soil	Soil erosion			x
		Soil organic and nutrient content		x	
	Climate Change	GHG emission related to iLUC			x
		GHG Reduction			x

Project Timeline: Start: 2011 - End: 2013 and Started again in 2017 and ongoing

Funding source: Total budget is €501,558**.** Supported by the European Regional Development Fund

Success elements (targets achieved) and Failures (obstacles and challenges faced):

Yields paying back the establishment of agroforestry system have been reached.

Innovation:

Latvia is a moderate innovator according to the European Innovation Scoreboard 2017 report[95]. Latvia has an innovation-friendly environment, good human resources whereas it is relatively weak in terms of research systems, innovators and collaborations among SMEs, and public-private partnership in research and development.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Research Institute

95 Ibid.

Case 11: Willow in Ukraine

Region +NUTS code: Volynska and Lviv districts (Western Ukraine)

Ukraine Map[96]

Demonstration/Implementation level: Regional

Size of the cultivated land: 11 hectares

Climate: Continental & Boreal (Zone 3 according to MAGIC classification of geo-climatic regions). In general willow is widespread in temperate climatic regions

Institution demonstrating/implementing the good practice: Salix Energy Limited[97] has over 1,700 hectares of energy plantations in Ukraine and is one of the largest industrial plantation in the Eastern European region. The company provides services such as preparatory works, field planting, management, and harvesting for growing energy crops. Salix Energy Limited is growing willow to produce wood chips which can be used in energy both for heat and electricity.

Introduction of the region and the Good Practice project:
According to the report by SEEMLA project on characteristics of marginal sites[98], this region in Western Ukraine is characterised as an area prone to waterlogging, flooding and has high underground water tables. The region has diverse soil conditions, from sandy soils to heavy soils with low water permeability to dense soil layers limiting the root depth and moderate soil acidification. Soil nutrient content is very low in these western Ukrainian regions as they have

[96] (Source of map: https://www.nationsonline.org/index.html)

[97] Salix Energy is a company whose main activity is the production of willow for biomass production. The company's first plantation was established in 2010 and in 2014 the first industrial crop was harvested. SALIX energy is the first company in Ukraine that started to export wood chips from energy plantations for customers in Poland and for the solid-fuel boilers in Ukraine. https://www.salix-energy.com/about

[98] Report on Characteristics of marginal land in pilot areas by SEEMLA. http://www.seemla.eu/wp-content/uploads/2017/01/Report-on-characteristics-of-MagL-in-pilot-areas_Seemla-5.2.pdf accessed online on 19th October 2018

not been used for agriculture activities since 1990s. The region has continental climatic conditions with cold winter months and higher temperatures in summer and maximum precipitation in the warmer season. The Volyn and Lviv region aridity index shows that they have humid conditions. The De Martonne Aridity index is 31.1 for the Volyn region) and 37.7 for the Lviv region[99].

Industrial Crop: Basket willow *(Salix Viminalis)*

Potential as an Industrial crop: Willow is a perennial lignocellulosic crop. Willow plantations are productive for 20-30 years and can be harvested every 2-3 years. The average yield of willow is 3-4 t dm/ha/yr and under favourable conditions the yield could be up to 20-30 t dm/ha/yr. In a 3-year growing cycle and for the yield of 10 t dm/ha/yr, fertiliser inputs recommended are: nitrogen 150 kg/ha, phosphorus 45 kg/ha, potassium 90 kg/ha, calcium 120 kg/ha and magnesium 30 kg/ha[100]. Willow re-distribute nutrients during the perennial cycle: in every 3-year period the abscised leaves add 20 kg of nitrogen to the soil requiring very minimal nitrogen fertiliser for growth[101]. Willow trees are resistant to pest, frost and diseases. 37 different Willow varieties were tested for saline tolerance and it was found that they can tolerate moderate ((ECe≤5.0 dS m−1 to severe (ECe≤8.0 dS m−1) saline condition[102]. Willow trees grown for phytoextraction can be used for energy purposes if composting is used as a pre-treatment method, however the ashes cannot be used as fertilisers due to their high toxic metal concentration[103]. Willow has higher content of lignin and lower cellulose and hemicellulose, which means higher energy value, lower ash content when compared with wheat and Miscanthus[104]. Nitrogen use efficiency (NUE) and water use efficiency (WUE) are both correlated with yield. Therefore, it is important to identify willow genotypes that can grow on marginal lands with limited water and nutrient conditions[105].

According to the Bioenergy Association of Ukraine (UABio) there are 3-4 Mha of unused agricultural land in Ukraine which can be used for energy crops. A few bio-based companies are already cultivating energy crops at commercial scale and with the introduction of promising state support (subsidy for energy crop plantation 10,000 UAH/ha) more companies will enter the market[106].

Marginality factor: Each region has its key assets which characterise its marginality conditions. These key assets are grouped in biophysical, economic, environmental and social cat-

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[99] Report on Characteristics of marginal land in pilot areas by SEEMLA. http://www.seemla.eu/wp-content/uploads/2017/01/Report-on-characteristics-of-MagL-in-pilot-areas_Seemla-5.2.pdf accessed online on 19th October 2018
[100] Ibid.
[101] Ibid.
[102] HANGS, R., SCHOENAU, J., VAN REES, K. & STEPPUHN, H. 2011. Examining the salt tolerance of willow (Salix spp.) bioenergy species for use on salt-affected agricultural lands. Canadian Journal of Plant Science, 91, 509-517.
[103] ŠYC, M., POHOŘELÝ, M., KAMENÍKOVÁ, P., HABART, J., SVOBODA, K. & PUNČOCHÁŘ, M. 2012. Willow trees from heavy metals phytoextraction as energy crops. biomass and bioenergy, 37, 106-113.
[104] KARP, A., HANLEY, S. J., TRYBUSH, S. O., MACALPINE, W., PEI, M. & SHIELD, I. 2011. Genetic improvement of willow for bioenergy and biofuels free access. Journal of integrative plant biology, 53, 151-165.
[105] Ibid.
[106] GELETUKHA, G., ZHELIEZNA, T. & TRYBOI, O. 2014. Prospects for the growing and use of energy crops in Ukraine. UABio Position Paper, 30.

egories. The case from the Volynska and Lviv districts from Western Ukraine has its own characteristics based on these selected key assets, the marginality factors and their marginality level as shown in the table below. The main marginality factor is low soil fertility.

			Marginality level		
Key Assets	Criterias	Indicators	High	Medium	Low
Bio-physical	Soil	Low Fertility	x		
		Excessive wetness		x	
	Climate	Adverse Climate			x
Economic	Funding	Private/public funds	x		
	Productivity	Crop Yield		x	
	Profitability	Growing Trade/Business prospect for biomass mobilization			x
Environmental	Resource Use	Conservation of Biodiversity	x		
		Water use efficiency		x	
		land use			x
Social and Institutional	Socio-economic Infrastructure	Increasing research and development activities	x		
		Creation of new jobs		x	
	Social Awareness	Knowledge about prospects of marginal lands			x

Project Timeline: Start: 01/2016 - End: 12/2018

Funding sources: € 134,086 - Supported by the European Regional Development Fund

Success elements (targets achieved) and Failures (obstacles and challenges faced): SALIX Energy Limited has contributed a good practice example as an agro-energy company. The services it provided at agronomic and technical levels have given us a success story of willow plantation establishment at an agronomical level for bioenergy (heat and electricity) production at an industrial scale.

Innovation: Successful establishment of willow as an energy crop – from cultivation to utilisation

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Bio-based Industry

Case 12: Miscanthus in Ukraine

Country: Ukraine

Region +NUTS code: Kyiv oblast, Ivankiv Region

Ukraine map[107]

Demonstration/Implementation level: Regional

Size of the cultivated land: >1000 Hectares

Climate: Continental & Boreal (Zone 3 according to MAGIC classification of geo-climatic regions)

Institution demonstrating/implementing the good practice: H2020 FORBIO project[108]

Introduction of the region and the 'Good Practice' project: Kyiv Oblast is the province surrounding the capital of Ukraine and falls in the Ivankiv region. It has mixed forests and half of the land is covered with forests and wooded areas. It has moderate continental climate with mild winters and warm summers. The region gets an annual precipitation of between 500-600mm and has wide river valleys with sandy-clay sediments. It has high groundwater levels and adequate moisture. The northern region of Ukraine is less populated than other regions due to post-Chernobyl socio-economic impacts and widespread unproductive and degraded lands. These lands have degraded and can no longer be used for commercial agricultural activities and are therefore no longer needed for production of food and feed crops.

The FORBIO project[109] is supported under the framework of H2020. The report produced by the project on the agronomic feasibility study of Ukraine, Ivankiv region. This region has abandoned agricultural land as well as degraded low productive land which is not suitable for

107 (Source of map: https://www.nationsonline.org/index.html)

108 https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-energy/biofuels-market-uptake/forbio

109 ZHELIEZNA, T., HAIDAI, O. & KOVACH, V. 2017. FORBIO Fostering sustainable feedstock production for advanced biofuels on underutilised land in europe: D2.5 Feasibility Study Ukraine -Agronomic Feasibility [Online]. Available: https://forbio-project.eu/assets/content/publication/20161212-FORBIO_agronomic%20feasibility%20Ukraine_CTXI_disclaimer.pdf [Accessed 23rd October 2018].

commercial agriculture. Therefore, the aim of the project was to conduct feasibility study of bioenergy feedstock production for the restoration of the land with poor soil and economic conditions. The knowledge gathered will be used for implementation of cellulosic value chains, biorefineries and alternative energy systems in the region.

Industrial Crops: Giant Miscanthus (*Miscanthus x giganteus)*

Potential as an Industrial crop: Miscanthus is a perennial lignocellulosic crop which was originally found in Asia and suitable in temperate climatic regions. Miscanthus plantation is productive for 15 years and can be harvested every year at an average yield of about 10 dm/t/ha[110]. Miscanthus does not require a big input of fertilisers due to good nutrient use efficiency (the maximum quantity of nitrogen is between 50 and 70 kg N/ha/year[111]). Giant Miscanthus is disease resistant and can grow in cold temperature in wet/heavy soil conditions. It can maximise yield by utilising up to 900 mm/year precipitation[112].

Miscanthus is suitable for biomass production because its lignocellulosic yields are high. It has low moisture content at harvest (10-25%), low free sugar and nitrogen content and high lignin content. All these traits make it suitable for thermochemical conversion to biofuel. Field trials[113] in midwestern United States have shown that giant Miscanthus biomass yields are higher than traditional switchgrass varieties. Therefore, as supported by other researches across US, it is suitable for use as feedstock for heat and electricity generation[114]. Miscanthus growth is restricted in moderate (9.8dS/m) saline soil condition and in extreme (5dS/m) conditions, plants do not survive[115]. The root system of Miscanthus can stand periodic low temperatures (up to -23°C) and can penetrate at the depth of 2 meters allowing effective use of the available moisture[116].

Marginality factor: Each region has its key assets which characterise it. These key assets are grouped in biophysical, economic, environmental and social categories. The case from Kyiv Oblast, Ivankiv Region of Ukraine has its own characteristics based on these selected key assets, the marginality factors and their marginality level as shown in the table below.

[110] NIXON, P. & BULLARD, M. 2001. Planting and growing Miscanthus, best practice guidelines. Department for Environmental, Food & Rural Affairs (DEFRA) Publications.
[111] GELETUKHA, G., ZHELIEZNA, T. & TRYBOI, O. 2014. Prospects for the growing and use of energy crops in Ukraine. UABio Position Paper, 30.
[112] Ibid.
[113] https://articles.extension.org/pages/26625/miscanthus-miscanthus-x-giganteus-for-biofuel-production#Current_and_Potential_Use_as_a_Biofuel
[114] HEATON, E. A., DOHLEMAN, F. G. & LONG, S. P. 2008. Meeting US biofuel goals with less land: the potential of Miscanthus. Global change biology, 14, 2000-2014.
[115] PŁAŻEK, A., DUBERT, F., KOŚCIELNIAK, J., TATRZAŃSKA, M., MACIEJEWSKI, M., GONDEK, K. & ŻUREK, G. 2014. Tolerance of Miscanthus× giganteus to salinity depends on initial weight of rhizomes as well as high accumulation of potassium and proline in leaves. Industrial Crops and Products, 52, 278-285.
[116] ZHELIEZNA, T., HAIDAI, O. & KOVACH, V. 2017. FORBIO Fostering sustainable feedstock production for advanced biofuels on underutilised land in Europe: D2.5 Feasibility Study Ukraine -Agronomic Feasibility [Online]. Available: https://forbio-project.eu/assets/content/publication/20161212-FORBIO_agronomic%20feasibility%20Ukraine_CTXI_disclaimer.pdf [Accessed 23rd October 2018].

			Marginality level		
Key Assets	Criterias	Indicators	High	Medium	Low
Bio-physical	Soil	Limitation in rooting			x
		Low Fertility	x		
		Excessive wetness			x
		Contaminated soil	x		
	Terrain	Adverse terrain			x
	Climate	Adverse Climate			x
Economic	Diversification of farmers incomes	Diversificationof rural enterprises (Industrial supply security and energy security)			x
		Diversification of farmers income (Flexibility and controllability)			x
	Productivity	Production costs			x
		Crop Yield			x
	Profitability	Revenues for farmers from unused land		x	
		Growing trade/business with prospect for biomass mobilisation		x	
	Competitive crops for bio-based markets	Increasing support for innovation activities		x	
		Increasing standardisation and certification of bio-based products		x	
	Funding	Private funds	x		
		Procedures to acquire funds	x		
		Annual Payment (Revenue made each year within a project time)	x		
	Land rent	(Revenue made each year within a project time)		x	
	Profitability	Revenues for farmers from unused land		x	
Environmental	Resource Use	Conservation of Biodiversity			x
		Land use			
	Water	Water availability			x
		Water use efficiency			x
	Soil	Soil erosion	x		
		Soil organic and nutrient content	x		
	Air	Air quality			x
		GHG emission related to iLUC			x
		Risk of contamination			
Social-Economic	Socio-economic Infrastructure	Increasing research and development activities			x
		Creation of new jobs			x
		Increasing support for human capital development (training and skills in new technology)			x
	Accessibility	Remoteness and rurality	x		
		Allocation and secure tenure of land	x		
	Policy	Presence of policy instrument (Effectiveness of policy)	x		
		Consistency of policy	x		
		Monitoring procedures	x		
	Population demography	Population, age density and institutional capacity		x	
	Cultural	Lack interest and mistrust about prospects of marginal lands			x
	Awareness	Knowledge on availability and prospects of marginal lands		x	

Project Timeline: Start: 01/2016 - End: 12/2018

Success elements (targets achieved) and Failures (obstacles and challenges faced): *Work is ongoing*

Innovation: Contribution of the project is lessons from good practices at the agronomic level as well as methodological implementation of bioenergy crops at industrial scale.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Research Institutions

Case 13: Napier grass in Dominican Republic

Country: Dominican Republic

Region +NUTS code: Caribbean

Demonstration/Implementation level: Regional

Size of the cultivated land: 200 hectares

Climate: Tropical (2100mm annual rainfall).

Institution demonstrating/implementing the good practice: Bioenergy Crops LTD, Local cooperative “ADEPROA” and Junta Agro-Empresarial (public-private consortia) in Dominican Republic.

Introduction of the region and the ‘Good Practice’ project: The project site in Dominican Republic was a land used for sugarcane 10 years before and then it was used for livestock rearing. The site was abandoned land for 5 years before ADEPROA together with Bioenergy Crops Limited started growing Napier grass using biochar-based compost. The land was abandoned because during sugarcane plantation, land was overgrazed which led to erosion and nutrient leaching. The biomass feedstock harvested is used to operate boiler for steam which is supplied to the textile industry, namely the Gildan Activewear Incorporation.

Industrial Crops: Napier grass

Potential as an Industrial crop: Napier grass is a perennial grass which is native to the African grassland ecosystem. The grass has low nutrient and water requirements making it suitable for marginal lands and has the potential to be an industrial crop because it has many uses as fodder, protein, fibres, biomaterials and bioenergy. Production of biogas from Napier grass through gasification and combustion process is demonstrated at a commercial level. Napier grass can produce 35-80 of oven dry tons/ha/yr. When harvested frequently it produces 8-16% crude protein fodder, and when harvested 1 or 2 times per year it is collected with 50% moisture from the field and can be used in a boiler after some drying in a patio or storage places. It can also be pre-treated by washing/leaching, screw press process for fibre cake and liquid fractions.
In this case study ash from boilers are used in compost operations and inoculants are applied into compost with biochar, gypsum and P rock (mineral, no synthetic fertiliser is used). Application rates of organic fertiliser is 3 to 8 dry tons/ha/year depending on crop requirements and specific soil constraints in each plot. No herbicides, insecticides or pesticides are used. Crop is harvested 2 times per year and regrowth is fast. Harvesting equipment and tractor use are main input requirements (diesel) during harvest operations. Crop maintenance may include tillage and de-weeding (mechanical). 1 ha of land can source seeds to plant a 30 ha plantation. Pearl millet and Napier grass interspecific hybrids are released.

Marginality Factors:
The main biophysical marginality factor at the project site is soil acidity (pH from 4 to 5.5). Soil in these regions tends to be too acidic for most crops and nutrient leaching, erosion (hydric erosion mainly) and lack of organic matter are frequent. Other major constraints are lack of farm equipment (such as planters, storage harvesters) and logistic chain such as storage

places for regular supply. In addition to this the human labour is not as skilled as knowledge is limited to sugarcane planting and some horticulture. In general lands which are used to grow sugarcane and livestock are abandoned in the Caribbean as it is more profitable to import food than producing sugar or beef mainly because of the lack of protein sources and animal feed.

			Marginality level		
Key Assets	Criteria	Indicators	High	Medium	Low
Bio-physical	Soil	Limitation in rooting			x
		Low Fertility		x	
		Excessive wetness		x	
	Terrain	Adverse terrain			
	Climate	Adverse Climate		x	
Economic	Accessibility	Infrastructure		x	
	Productivity	Crop Yield		x	
	Funding	Private funds		x	
	Land rent	(Revenue made each year within a project time)		x	
Environmental	Resource Use	Conservation of Biodiversity		x	
		Land use		x	
	Water	Water availability	x		
	Soil	Soil erosion			x
		Soil organic and nutrient content			x
	Climate change	GHG emission related to iLUC	x		
		GHG reduction	x		
Social and Institutional	Socio-economic	Accessibility	x		
		Infrastructure		x	
	Policy	Presence of policy instrument (Effectiveness of policy)	x		
		Consistency of policy		x	
		Monitoring procedures		x	
	Population demography	Population, age density and institutional capacity		x	
	Cultural	Lack interest and mistrust about prospects of marginal lands		x	
	Awareness	Knowledge on availability and prospects of marginal lands	x		

Project Timeline: Start: Not specified End: May 2017

Funding source: € 1 Million. Supported by private companies.

Success elements (targets achieved) and Failures (obstacles and challenges faced):
Due to the economically feasible success results of the project, the Bioenergy Crops Limited is trying to scale up the project with a second boiler with a capacity of 25 ton/hr steam and grow additional 600-800 ha of Napier grass as the way forward. Bioenergy Crops Limited is trying to control the moisture content during the harvesting process and have tested pre-

treatment options for storage and drying. The improved harvesting equipment will be in use in the near future. They are also looking into novel breeding to create hybrids of *pennissetum purpuerum x glaucum*.

Innovation: Extensive management for composting operations, logistic systems, harvesting solutions and storage/pre-treatment.

Stakeholders Involvement in the demonstration and implementation of the Good Practices: Local cooperative ADEPRO, farmers association Coop-Caña, Junta Agrop-Empresarial (JAP), Ministry of Agriculture

5. Indicators

Indicators are quantitative or qualitative factors or variables providing means to measure achievement, to reflect changes, or to help assess performance or compliance, and - when observed periodically - demonstrate trends. Indicators should convey a single meaningful message (information). Indicators have to be judged on the scale of acceptable standards of performance. Closely related indicators are **verifiers** which provide specific details that would indicate or reflect a desired condition of an indicator. They are the data that enhances the specificity or the ease of assessment of an indicator, adding meaning, precision and usually also site-specificity.

5.1 Key performance indicators for Good Practices

The Good Practices for assessing the use of marginal land for energy crops can be split in the following themes:

- Improve innovation across the value chain
- Efficient use of resources
- Sustainable and improved ecosystem services
- Smooth operation of business & markets
- Job creation

Each of these themes are analysed in or across technical, environmental, economic and socio-economic context where applicable.

Several indicators have been adapted from the Eurostat list of Agri-environment indicators[117] and the list of CAP impact indicators[118]. Others are also derived from the GBEP sustainability indicators for bioenergy[119] and the key criteria and indicators listed in the Biomass Futures project[120] and Biomass Policies project[121]. They were also aligned with other on-going projects like S2BIOM[122] and BioTrade2020+[123]. A key reminder is that this work is still evolving, thus additional changes are anticipated as these initiatives further progress.

The following table shows the indicators as broken down by stage of the value chain (from land, to primary biomass production, to conversion and end use) which are used to quantitatively or qualitatively evaluate different criteria. There are three types of indicators:

1. **Quantitative**: indicator can be monitored through a unit of measurement

[117] https://ec.europa.eu/eurostat/web/agri-environmental-indicators/indicators
[118] EU Commission (2014) REGULATION (EU) No 834/2014 Common Agricultural Policy Impact Indicators, https://ec.europa.eu/agriculture/cap-indicators_en
[119] GBEP (2011). The Global Bioenergy Partnership sustainability indicators for bioenergy. December 2011
[120] U. Fritsche et al. (2012). Sustainable bioenergy: key criteria and indicators. Deliverable D4.1 of the Biomass Futures project (IEE).
[121] www.biomasspolicies.eu
[122] www.s2biom.eu
[123] www.biotrade2020plus.eu

2. **Qualitative**: indicator can be monitored based on negative to positive impact scale assessment
3. **Descriptive**: provides information about key characteristics not easy to compare but relevant for assessing the value chain

Table 2 Key performance indicators for Good Practices

Good Practice theme	Sector	Indicator	Value Chain Stage	Quantitative	Qualitative	Descriptive
Innovation across the value chain	Technical	Crop heat resistance	Biomass Production			
		Crop drought resistance	Biomass Production			
		Crop disease resistance	Biomass Production			
		Crop nitrogen fixing	Biomass Production			
		Crop bioremediation	Full value chain			
		Crop installation	Biomass Production			
		Conversion efficiency	Conversion			
	Environmental	Life cycle GHG emissions reduction	Full value chain			
	Economic	Financial support mechanisms for innovation	Full value chain			
		Financial support mechanisms for certification	Full Value Chain			
	Socio-economic	Human capital development	Biomass Production and Conversion			
Efficient use of resources	Technical	Agroforestry input	Full value chain			
		Mulching, manuring, soil amendments	Land and Biomass Production			
		Rotation/soil cover	Land, Biomass Production			
		Irrigation and drainage	Biomass Production			

		Terracing and contour treeline	Biomass Production			
		Tillage	Biomass Production			
		Energy footprint	Full value chain			
		Bio-based material footprint	Full value chain			
		Integrated pest management	Land, Biomass Production			
	Environmental	Land footprint	Land, Biomass Production			
		Erosion prevention	Land, Biomass Production			
		Nitrogen use efficiency	Land, Biomass Production			
		Water use efficiency	Land, Biomass, Conversion			
		Phosphorus levels	Land, Biomass			
Sustainable and improved ecosystem services	Environmental	High nature value farming	Land, Biomass			
		Soil quality	Full value chain			
		Air quality	Full value chain			
		Water quality	Full value chain			
		Farmland bird index	Land and Biomass			

		Invasive species Index	Land and Biomass			
		Biodiversity rates	Land and Biomass			
Smooth operation of business & markets	Technical	Energy supply	Conversion/End use			
		Infrastructural accessibility	Conversion /End use			
	Economic	Levelised life cycle costs	Full value chain			
		Net added value	Full value chain			
		Productivity	Full value chain			
		Profitability	Full value chain			
		Diversification of rural industry	Full value chain			
	Socio-economic	Agricultural income	Land and Biomass production			
		Regional funding	Full value chain			
		Demographic composition	Full value chain			
		Social awareness and capital	Full value chain			
Jobs	Socio-economic	Agricultural employment structure	Land and Biomass production			
		Employment footprint	Full value chain			

5.2.1 Innovation Across the Value Chain

Technical Innovation

Crop heat tolerance

Descriptive

Heat stress is one of the major abiotic stresses that reduce crop productivity. Heat tolerance in crop plants is reported to have been achieved by genetic engineering of expression of heat shock proteins, increasing the level of osmolytes and various cell detoxification enzymes, and altering membrane fluidity.

Crop drought/salinity resistance

Descriptive

Different crops have different thresholds for withstanding soil sodium salinity.

Lack of watered soil is usually accompanied with high salinity levels and each crop has a certain threshold resistance. A distinction is made between plants able to tolerate only low levels of salinity (glycophytes) and those really adapted to saline soils (halophytes). Here we may include the cultivation of tolerant crops for reclaiming salinized soils, however, most crops are glycophytes and able to withstand only moderate levels of salinity, and only a few can be considered halophytes[124]. Some plants can perform ***reverse salinisation*** by accumulating salts in their cells and/or secreting it through specials organs. The idea implies the later disposal of the above ground material and the continuous growing of them to reverse salinization levels and reclaim salinized lands.

Crop disease/pest resistance

Descriptive

Resistance is the ability of a plant variety to restrict the growth and development of a specified pathogen/pest or the damage they cause when compared to susceptible plant varieties under similar environmental conditions and pathogen/pest pressure.

Crop nitrogen fixing capabilities

Quantitative

Many catch crops and certain biomass crops can preserve soil nitrogen and decrease nitrogen leaching losses through biological nitrogen fixation from the atmosphere, as well as

[124] Oenema, O., Heinen, M., Rietra, R., Hessel, R. (2017) A review of soil-improving cropping systems, Soilcare for profitable and sustainable crop production in Europe

through root-derived fixation. Species such as black locust have nitrogen-fixing bacteria in their root systems, which make them more capable of growing in poor soil conditions.
This indicator is expressed in ***nitrogen fixation rate in kg N ha^{-1} per year^{-1}***.

Crop bioremediation of heavy metals

Quantitative

Marginality of land can often be attributed to land with contamination from landfill and waste disposal, heavy metals or post-mining operations, war affected zones, transport spills, and storages of chemical substances such as oil or obsolete chemicals. There are for four main metals: cadmium, zinc, lead and nickel. Cadmium has several more anthropogenic sources. It is a wide spread contamination problem as it occurs where too intensive phosphate fertilisation has taken place. It is a large contamination problem worldwide[125] with at least 340,000 sites contaminated with metals and oil in Europe, 80,000 in Australia and at least 20 million hectares of farmland contaminated with heavy metals in China. Soil characteristics are very influential on whether plants can take up metals easily, particularly the pH level is key which is strongly influenced by levels of calcium.

Phytoremediation, or bioremediation, is a set of remediation techniques based on the use of tolerant plants and their microorganisms to decrease pollution risks due to excessive contaminants in soils, water, and sediments. A key target is to choose appropriate plants that are able to contain soil contamination, since marginal lands have already lower agricultural value. Miscanthus are an example of a non-food crop with the capacity to accumulate trace elements in roots, limit its transfer to shoots, promote degradation of organic xenobiotics and improve soil quality of contaminated sites[126].

Soil contamination from heavy metals and other pollutants can be dealt with by 1) withdrawing pollutants with phyto-remediating crops[127], 2) amending soil to stimulate biological breakdown or lock-up organic pollutants, and 3) growing bio-energy crops.

Indicators are changes in ***1) heavy metal content in soil, 2) percentage of critical load exceedance by sulphur and nitrogen, 3) concentration of persistent organic pollutants, and 4) topsoil pH. Extraction of soil pollutants is measured in µg kg-1.***

Crop installation techniques

Descriptive

Plantations can be done using seedlings. Root cuttings, shoots and grafts may be used for propagation. Before sowing, seeds can be scarified, and processed by grinding sand, grating or by treating with boiling water. They can be placed to a certain depth. Then

[125] FAO (2015) Status of the world's soil resources, http://www.fao.org/3/a-i5228e.pdf
[126] Nsanganwimana, F., Pourrut, B., Mench, M., Douay, F. (2014) Suitability of Miscanthus species for managing inorganic and organic contaminated land and restoring ecosystem services. A review, *Journal of Environmental Management*, 143: 123-134
[127] Šyc, M., Pohořelý, M., Kameníková, P., Habart, J. (2012) Willow trees from heavy metals phytoextraction as energy crops, *Biomass and BioenergyBiomass and Bioenergy, 37:106-113*

seedlings can be dug up and placed in a permanent place. Planting can be done by hand or using a planting machine.

Perennial energy plants that reproduce by seeds shall be sown in rows using grain-grass drills. Immediately after seeding (especially for small-seeded plants) rolling the soil surface with smooth rollers shall be done. This improves seed contact with the soil and provides its best germination.

Conversion efficiency for bio-based product

Quantitative and descriptive

Indicators for conversion efficiency are pre-treatment costs of the feedstock, logistics for storage and transportation and any steps leading to the readiness of feedstock conversion. Any self-sufficiency aspect of the supply chain can be highlighted through this indicator, for instance any nutrient, waste, water, or material recycling which can be used during conversion.
A sub indicator is the energy inputs/outputs required for conversion.

Environmental Innovation

Life cycle greenhouse gas emissions reduction potential

Quantitative/Comparative to fossil fuel reference

Greenhouse gas (GHG) emissions, with the main greenhouse gases being CO_2, methane (CH_4) and nitrous oxide (N_2O), have to be considered over the full value chain (biomass supply – logistics – conversion – distribution – use).

They are typically expressed in ***% GHG reduction***. Sub-indicators are expressed in ***kg CO2-equivalent per tonne and /or per GJ outputs***.

As the combustion of biomass is considered CO_2-neutral (the emitted carbon has been absorbed from the atmosphere during plant growth), the GHG balance mostly concerns the use of fossil energy in the chain, e.g. for transport, external heat, electricity or fossil inputs. In some cases, CH_4 and N_2O emissions need to be considered, when dealing with land use and agricultural processes, or even the production of fertilisers (more important for non-woody biomass). However, positive LUC effects occur when cropping leads to higher soil organic matter content, thus having a net greenhouse gas emissions reduction. This is known as carbon stock changes, which are annualised in a 20-year time frame.

Fossil fuel reference: reference situation where the same services are produced (heat, electricity, transport fuels and materials) for fossil fuels.

Eurostat baseline: Greenhouse gas emissions should be reduced by 20% compared to 1990.

Economic Innovation

Financial support mechanisms for innovation activities

Descriptive and quantitative

Indicator is the type of mechanism, monetary value and stage of the value chain with financial support.

Financial support for innovation activities in biomass production depends on the ***availability of funding under annual payment schemes***, as well as general funding research and development activities and investments.

Financial support mechanisms for certification of bio-based products

Descriptive and quantitative

Indicator is the type of mechanism, monetary value and which bio-based product is supported financially for certification.

Socio-economic Innovation

Human Capital Development

Descriptive

Conservation agricultural techniques for industrial crop growth in marginal lands is a complex, site-specific farming system, requiring training of farmers and adaptation to local circumstances before maximum economic benefits can be obtained. Actors involved along the value chain require human capital support mechanisms which can broaden their expertise. The use by farmers of advisory services would also allow and help them to improve the sustainable management of their holdings and to adapt, improve and facilitate the overall performance of the holdings by enhancing the human potential of the agricultural and forestry sector.

Vocational training is a training measure or activity, provided by a trainer or a training institution which has as its primary objective the acquisition of new competencies related to the farm activities or activities related directly to the holding or the development and improvement of existing ones. Vocational courses are typically clearly separated from the active work place (learning takes place in locations specially assigned for learning, a class room or training centre). They exhibit a high degree of organisation (time, space and content) by a trainer or a training institution. According to the CAP indicator on Agricultural training of farm managers, training ranges from:

1. ***practical experience/no formal training***: experience acquired through practical work
2. ***basic agricultural training*** any training courses completed at a general agricultural college or institution specialising in subjects such as horticulture, viticulture, silviculture, pisciculture, agricultural technology and other); a completed agricultural apprenticeship is regarded as basic training
3. ***completion of a full cycle of agricultural training***: any training course continuing for the equivalent of at least two years full time training after the end of compulsory education and completed at an agricultural college or institution specialising in horticulture, viticulture, silviculture, pisciculture, agricultural technology and others

There are additional indicators built on the basis of administrative data reported by Member States in compliance with the requirements of the Rural Development Programmes: share of the number of participants in environmental vocational trainings and information actions (including training and information actions on management, administrative and marketing skills, ICT trainings, product quality, etc., share of number of farmers' applications for the use of environmental advisory services (including advice for occupational safety standards, animal welfare, economic performance, etc.), share of economic actors supported by rural development policy for training and information actions addressing the maintenance of landscape and the protection of environment

5.2.2 Efficient Use of resources

Technical Efficiency

Land improvement by agroforestry input

Descriptive

Agroforestry is the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions (den Herder et al, 2016). This indicator is linked to cropping rotation systems, nitrogen use efficiency, erosion rate, contour planting, since alley cropping systems are multipurpose and represent a low-input system with a reduced demand of fertilisers, water and manpower, attributes which are highly desirable for low fertile soils or reclamation sites[128]. There are five basic types of agroforestry in European temperate areas: silvoarable agroforestry, forest farming, riparian buffer strips, silvipasture, improved fallow and multipurpose trees[129].

Silvoarable agroforestry involves widely spaced trees inter-cropped with annual or perennial crops, comprising alley cropping, scattered trees and line belts. Systems can be mixed dense, mixed sparse, laid in strips or in boundaries, overlapping or separate in temporal arrangements, with either low, medium or high technological level inputs, commercial, intermediate or subsistence management level. Functions range from provisioning services to habitat functions, to regulating and finally cultural functions[130].

The AGFORWARD project (Agroforestry for Europe) contains 10 Best practice leaflets for reference on how to operationalise alley cropping systems, choosing the right site and tree species, planting material, protecting trees against wildlife damage, preparing land, and mulching strategies.

Land improvement by mulching, manuring and soil amendments

Descriptive

Soil amendments in the form of mulching, manuring or organic waste such as compost can significantly improve nutrient recycling to reduce the losses of nutrients and soil fertility.

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[128] Quinkenstein, A., Wöllecke, J., Böhm, C., Grünewald, H., Freese, D., Schneider, B.U., Hüttl, R.F. (2009) Ecological benefits of the alley cropping agroforestry system in sensitive regions of Europe. Environmental Science & Policy, 12 (8), 1112-1121.

[129] Mosquera-Losada, M.R., McAdam, J., Romero-Franco, R., Santiago-Freijanes, J.J., RigueroRodríquez, A. (2009) Definitions and components of agroforestry practices in Europe. Agroforestry in Europe: Current Status and Future Prospects, 3-19.

[130] den Herder, M., Burgess, P., Mosquera-Losada, M.R., Herzog, F., Hartel, T., Upson, M., Viholainen, I., Rosati, A. (2015) Preliminary stratification and quantification of agroforestry in Europe, AGFORWARD Agroforesty in Europe

Soil amendments can also come in the form of chemicals such as elementals S, acids and gypsum[131] as well as bio-char. Amendments constitute crop residues which support nutrient recycling and improving soil structure and quality. Resides are materials usually not taken away but rather left in a field or orchard after the crop has been harvested. They include stalks, stubble, leaves, roots and seed pods. Benefits to soil structure and soil fauna depends on amount, quality and timing. Additional effects of residue removal/retention can either be positive or negative in terms of impacts on pests and disease[132].

Land improvement by rotations/soil cover

Descriptive

Soil cover, i.e. periods of the year when soil is covered by crops, including catch/cover crops, is important for preventing nutrient and pesticide runoff. In addition, soil cover may improve soil fertility and reduce the risk of soil erosion. These impacts are linked with information about intercropping and tillage systems. Cover crops can provide vegetative cover between rows of main crops or between periods of arable crops. They can also function as catch crops, which incorporate the remaining nitrogen after the main crop is harvested, thus reducing losses from leaching[133]. Crop rotations contribute to conservation agriculture techniques aimed at targeting the upper 0 – 20 cm zone of soil and prevent it from further degradation and erosion[134].

Cover crops are crops grown mainly to reduce soil erosion by covering the ground with living vegetation and living roots that hold the soil.

Green manure crops are crops grown to help maintain soil organic matter and fertility.

Catch crops are crops grown to retrieve remaining nutrients in the soil following a cash crop, prevents nutrient loss over the winter. Statutory catch crops, i.e. under sown grass or crucifers sown just before or after harvest and ploughed before sowing the next crop, are included in the legislation in some countries to reduce nitrate leaching during autumn and winter.

Overall environmental impacts of soil cover on biotic and abiotic resources are the following: green cover and mulch provide habitats from many species and both contribute to

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[131] Shahid, S. A. and Al-Shankiti, A. (2013) Sustainable food production in marginal lands – Case of GDLA member countries, International Soil and Water Conservation Research¸1, 1: 24-38

[132] Ten Berge, H. F. M., Schröder, J. J., Olesen, J. E., Giraldez Cervera, J. V. (2017) Research for AGRI Committee - Preserving agricultural soils in the EU, Policy Department for Structural and Cohesion Policies, European Parliament

[133] Ten Berge, H. F. M., Schröder, J. J., Olesen, J. E., Giraldez Cervera, J. V. (2017) Research for AGRI Committee - Preserving agricultural soils in the EU, Policy Department for Structural and Cohesion Policies, European Parliament

[134] Shahid, S. A. and Al-Shankiti, A. (2013) Sustainable food production in marginal lands – Case of GDLA member countries, International Soil and Water Conservation Research¸1, 1: 24-38

the increase of soil fauna and flora by nutrients, more carbon dioxide gets fixed by crops and intercrops, soil fertility leads to a decrease of N2O release, covered land lowers the risk of losing nutrients and decreases runoff and water erosion, finally cover crops slow down and potentially reverse degradation processes.

Land improvement by irrigation and drainage management

Quantitative and descriptive

This indicator can be quantified by using volume of water used for irrigation and qualified with water source used for irrigation, as well as the various methods of irrigation:
Surface irrigation (also called 'flood irrigation') i.e. the leading of water along the ground, either by flooding the whole area or leading the water along small furrows between the crop rows, using gravity as a force;

Sprinkler irrigation i.e. irrigating the plants by propelling water under high pressure as rain over the parcels;

Drop irrigation i.e. irrigating the plants by placing water low by the plants drop by drop or with micro-sprinklers or by forming fog-like conditions.

Sprinkler and drop irrigation methods are less water-intensive than surface irrigation. Equipment for drop irrigation is more expensive than for other irrigation methods and this system therefore tends to be concentrated in areas with high-value crops.

This indicator can be linked to water use efficiency and life cycle costs. Since irrigation is a major driving force behind water abstraction, it can exacerbate the marginality factor rather than remediate the land. Trends in water abstraction rates depend on various factors: crop variety, irrigation area, irrigation technology, water prices, water restrictions, pumping costs and climate conditions. The environmental impact of irrigation is however depending on the water abstraction rate, the water availability at local level and the water sources used for irrigation also matter, e.g. surface water can be replenished much faster than groundwater. Irrigation can have environmental benefits: redistribution of water resources, new irrigation projects can contribute to improvement of aquifer recharge and habitat conservation in the areas receiving the new water.

Land improvement by terracing or contour treelines

Descriptive

According to the World Agroforestry Centre, contours are level lines across a slope at a constant elevation[135]. Contours may curve from side to side to stay level, but they never upslope or downslope. Vegetative barriers (such as grassy strips) are be located on the contour to control soil erosion. Water flowing down the slope picks up soil. When it reaches a contour barrier it slows down, the soil particles settle out, and more water enters the soil.

[135] Young, A. (1997) The effectiveness of contour hedgerows for soil and water conservation, *Agroforestry Forum*, 8 (4): 2-4

Land improvement by tillage practice

Descriptive

Marginal lands can be improved according to either ***conventional, conservation/reduced or zero/no tillage***. Tillage practices are physical methods for implementing soil reclamation to diagnose soil salinity, sodicity, and depth barriers to root penetration, and establish a technique which is sustainable for any given climatic zone, biomass and land[136].

Conventional tillage includes inversion ploughing whereas conservation tillage foregoes the use of ploughs and is characterised by direct sowing (also called direct drilling or no-tillage), reduced tillage (also called mulch tillage or minimum tillage), zone, strip or row tillage, surface incorporation of crop residues and cover crops.

Links to other indicators: The information about tillage practices helps assess other indicators as such on soil cover, risks of nitrate leaching, and organic matter of soils. Any disturbance of soils may enhance turnover of nutrients and thereby increase the potential risk of loss of, for example, nitrogenous compounds and phosphorus through surface runoff and soil erosion. No - and reduced tillage (NT and RT) can diminish spring time run-off and erosion, provided the soil is sufficiently covered. However no-tillage combined with no soil cover can result in a significant increase in water erosion. Soil compaction occurs when mechanical pressure is applied, especially in wet conditions. It is assumed that with no-tillage, the number of tractor passages decreases significantly; which is not always true under reduced tillage. The reduced number of tractor passages on fields under NT or RT should result in a reduced compaction risk. Zero tillage is a fundamental principle of conservation agriculture where low-disturbance seeding techniques for application of seeds and fertilizers gradually increases organic matter of the surface layers because of reduced biological oxidation compared to conventionally tilled soils[137].

Additionally, reduced tillage may in the short-term lead to increased use of herbicides in order to compensate for the reduced mechanical weed control. Further, reduced tillage may contribute to carbon sequestration in soil and thereby impact soil organic carbon levels as well as the emissions of greenhouse gases (GHG).

Energy footprint

Quantitative

Energy efficiency can be measured by comparing the energy content of all inputs of the value chain with the energy content of all the outputs, including both renewable and non-renewable sources. Where most non-renewable source can be spent and potentially outweigh renewable energy outputs is the thermal efficiency of the conversion process and the

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[136] Shahid, S. A. and Al-Shankiti, A. (2013) Sustainable food production in marginal lands – Case of GDLA member countries, International Soil and Water Conservation Research¸1, 1: 24-38

[137] Dumanski, J., Peiretti, R., Benites, J. R., McGarry, D. & Pieri, C. (2006) The Paradigm of Conservation Agriculture, *Proceedings of World Association of Soil and Water Conservation,* P1: 58-64

distance between the biomass production site, the conversion site and distribution network. A second key point is the self-sufficiency of the plant.

Inputs: Energy content of the biomass feedstock, Primary energy of fuel inputs (non-renewable and renewable), Primary energy required to produce heat and electricity inputs, Primary energy required to produce materials input

Inputs are the direct use of energy (solid fuels, total petroleum products, gas, electricity, renewables, and heat) by agriculture per ha of utilised agricultural area (UAA). It assesses the trend of energy consumption, per ha and per fuel type and is expressed as total direct energy use at farm level in KgOE per ha per year.

Outputs: Energy content of the final products (fuels, electricity, heat, materials), Energy content of co-products, Energy content of residues

The indicator comparing inputs to outputs is typically expressed in ***GJ input / GJ output***. The higher the indicator, the more input is needed to achieve a certain output (expressed in energy terms).

Eurostat baseline: share of renewable energy sources in final energy consumption should be increased to 20% and energy efficiency should improve by 20%

Bio-based material footprint

Quantitative and qualitative

The ***secondary use*** of resources is used an indicator of the bio-based material footprint since it represents the share of input material that can be re-used as a secondary resource.

This indicator can partly be expressed in % of the input material (in ton dry mass) to be secondary resource. Nevertheless, the use of residues (which can also have alternative applications) is not by definition positive, so there should also will be a descriptive part. There can also be a distinction in type of material used, indicating to which extent the process relies on fresh material or residues which can be used for higher value purposes:

--	Fresh material (high value), which can also be used for material / food
-	Residues, which can also be used/recycled for material or animal feed
o	Fresh material, but difficult to use for material / food
+	Residues, difficult to use for material / food
++	Non-recyclable waste as input

Integrated pest management

Descriptive

Integrated pest management comprises the joint use of a range of pest-control strategies (insects, weeds or disease) in a way that reduces pest damage to below economic thresholds and is sustainable and non-polluting[138]. It includes mechanical, chemical, natural, biological controls, each with different potential impacts on soil, water and biodiversity. There are also potential links between controlled natural predation, biodiversity changes and intercropping or agroforestry.

Pesticide contamination of groundwater and rivers can be potentially damaging to endemic species, biodiversity and communities downstream. It can be monitored as either ***groundwater with pesticide concentrations or rivers with annual average pesticide concentrations above Environmental Quality Standards (EQS)***.

Pesticides are used to control pests, weeds and diseases in agriculture, and their use plays an essential role in maintaining or enhancing crop yields. Pesticides are rigorously risk assessed before being approved for marketing. However, their use, particularly if it doesn't follow relevant guidance, can lead to harmful effects upon non-target organisms in the wider environment, including aquatic ecosystems. Risks to human health can also arise. Several pesticides are persistent (slowly degraded), bioaccumulated (concentration increases in biota), bioconcentrated (concentration in biota increases through the food chain), and mobile in the environment (high water solubility and low absorption to soil). In addition to acute and chronic toxic effects on non-target biota, a large range of pesticides has been shown to possess potentially endocrine-disrupting properties, as well as causing impairment of the nervous system and cancer.

Pesticides used in agriculture are transported by diffuse pathways to surface and groundwater. Point discharges are also important, however, and occur through accidental spillage, sprayer loading and wash-down and inappropriate storage and disposal. The contamination of surface and groundwater by pesticides impairs the quality and restricts use as drinking water. In aquatic ecosystems elevated concentrations of pesticides may result in a reduction in population density and loss of biodiversity. Today several European water bodies are at risk from diffuse pollution by pesticides.

The EU pesticide statistics regulation[139] has identified close to 500 active substances to be followed; usage data are reported for Europe grouped in almost 120 substance classes, some of which include a high number of chemicals with markedly different physics-chemical properties, hence fate and toxicity to humans and ecosystems. The environmental concentration of pesticides depends substantially on application timing and mode, climate and landscape parameters. Among other parameters, soil organic carbon content, the distance of the application site from water bodies, the presence of buffer vegetation, ambient temperature, and runoff and leaching rates play a major role.

[138] Pretty, J. (2002) *Agri-Culture: Reconnecting People, Land and Nature*, Earthscan
[139] Regulation (EC) No 1185/2009 of the European Parliament and of the Council of 25 November 2009 concerning statistics on pesticides

Environmental Efficiency

Land footprint by sustainable harvest levels

Quantitative

This indicator is relevant for the harvest of trees, wood resources and the removal of wood harvest residues (including stumps), but also the removal of agricultural residues such as straw and stubbles and pruning residues from permanent crops. This indicator links to the soil organic carbon indicator (also included in carbon stock change for GHG emissions) but goes further as it also includes above ground carbon storage (in biomass).

The annual harvest of wood, agricultural and biomass resources (materials and energy) is expressed as ***a percentage of net growth or sustained yield, and the percentage of the annual harvest used for bioenergy***. In a sustainable harvesting situation, long-term harvest levels should remain lower than net growth and forests or arable lands are allowed to expand their carbon storage. If not, there may be net depletion of biomass stands, meaning that it can't be considered a 'renewable' resource.

Erosion rate and linked prevention practice

Quantitative and qualitative

This indicator expresses the risk for soil erosion where the aim should be to select biomass crops and cultivation practices that do not add to increasing the risk but should rather decline the risk for water and wind erosion, particularly in regions where erosion is already a threat. Erosion risk depends on location and soil type. Perennial crops have a lower risk than rotational crops by providing soil structure and stability and soil quality and biodiversity as compared to annual species. Perennial grass species such as giant reed and Miscanthus help to contain soil erosion in sloping areas, increase carbon storage in the soil, and provide lignocellulosic biomass for energy and advanced biofuels[140]. Removal of stumps in forestry practices creates high erosion risk.

This indicator can be measured as the ***estimated rate of soil loss by water erosion in t ha-1 / year-1.***

If the rate of erosion cannot be calculated, there are certain biomass types, indicators (such as tillage, agroforestry, nutrient recycling, mulching…etc.) and practices which can highlight whether there is a general high risk, no link or reverse impact on soil erosion.

Indicative qualitative scoring:

--	High risk for soil erosion when growing and harvesting this type of biomass and using this type of practice(s)
-	
o	No relation to soil use

[140] Cosentino, S. L., Copani, V., Scalici, G., Scordia, D., Testa, G. (2015) Soil Erosion Mitigation by Perennial Species Under Mediterranean Environment, *BioEnergy Research,* 8(4): 1538-1547

+	
++	Growing and harvesting this type of biomass with this type of practice(s) declines the risk of soil erosion

Nitrogen loss prevention measured by nitrogen use efficiency

Quantitative

Nitrogen use efficiency is defined as ***total nitrogen outputs divided by total nitrogen inputs***. It gives an indication of the relative utilisation of nitrogen applied to an agricultural production system. In principle, by decreasing the nitrogen surplus over time, the nutrient use efficiency increases, where it remains low if the nitrogen output in harvest products is relatively low and the nitrogen output is high[141]. It can also be calculated as the ***potential surplus of nitrogen on agricultural land (kg N per ha per year)***.

A high efficiency does not necessarily indicate a sustainable system: rates which may be close to or above 1.0 (nitrogen output/nitrogen input) would indicate a risk of soil depletion, as the nutrient uptake by crops exceeds the amount of nutrients applied to the soil.

Inputs usually consist of: inorganic and organic fertilisers, manure production, input, withdrawals, seeds and planting material, biological nitrogen fixation by leguminous crops, trees and grass-legume mixtures, and atmospheric deposition.

Outputs usually consist of: Total removal of nitrogen with the harvest of crops, harvest and grazing of fodder, and removal of crop residues from the field.

Not all of nitrogen in fertilisers and manure reaches the crop. Part of the nitrogen is lost due to volatilisation in animal housing, storage and during application to the land. Moreover, organic nitrogen in manure first needs to be mineralised before being available to the crop, which means that part of the nitrogen may need different amounts of time for being available to plant (depending on soil characteristics and climate conditions – temperature and precipitations). Yield and therefore the uptake of nitrogen by crops is not only determined by inputs but also by non-controllable factors like weather. Furthermore, the risk of nitrogen leaching and run-off does not only depend on the nitrogen excess, but also on the type of soil, precipitation rates, soil saturation, temperature, etc. Abating measures to reduce nitrogen emissions directly impact the amount of nitrogen in manure and fertilisers applied to the soil. A higher emission rate means lower nitrogen content of manure/fertilisers applied to the soil but means a higher contribution to environmental problems related to GHG and NH3 emissions. Lowering the emission rate means increasing the rate of nitrogen in manure/fertilisers, and therefore increasing the potential risk of leaching and run-off.

Therefore, the estimated nitrogen surplus by itself does not determine the actual risks to the air, water and soil. The actual risk depends on many factors including climate conditions, soil type and soil characteristics, soil saturation, management practices such as drainage, tillage, irrigation, etc. However, the gross nitrogen balance indicator presents a link be-

[141] Quinkenstein, A., Wöllecke, J., Böhm, C., Grünewald, H., Freese, D., Schneider, B.U., Hüttl, R.F. (2009) Ecological benefits of the alley cropping agroforestry system in sensitive regions of Europe. Environmental Science & Policy, 12 (8), 1112-1121

tween the agricultural activities and the environmental impact and identifies the factors which determine the nitrogen surplus and shows the change over time.

Water footprint measured by water use efficiency

Quantitative/comparative to biomass reference

Water use for biomass production, irrigation and processing is calculated in ***m3 water / GJ outputs***.

In the case of marginal lands, water levels can already exhibit high stress or depletion rates. Negative environmental consequences of excess irrigation and additional water depletion from newly established cropping activities with deep rooting crops or trees can occur.

However, certain cropping systems can increase either groundwater or watershed levels.

Water availability is a sub indicator which can monitor this change: water footprint, together with existing agricultural, industrial and human water uses must not exceed the average replenishment from natural flow in a water.

Water use efficiency can also be measured during the primary biomass production stage in order to assess how a particular crop performs in terms of water needs.

Phosphorus levels

Quantitative/comparative to fossil fuel reference

Phosphorus levels are calculated ***in kg P per ha per year***.

Inputs come from inorganic and organic fertilisers (sewage sludge, compost, mulch, waste products), gross manure input (production, withdrawals, imports), seeds and planting.

Outputs come from removal of phosphorus through the harvest of crops, the harvest and grazing of fodder and crop residues removed from the field.

Sustainable levels of phosphorus lie between a persistent surplus indicates potential environmental problems, such as phosphorus leaching resulting in pollution of drinking water and eutrophication of surface waters, while a persistent deficit can impair the resource sustainability of agriculture soil through soil degradation, or soil mining, resulting in declining fertility in areas under crop or forage production.

A sustainable use of phosphorus is needed to ensure food supply in the future and to reduce negative impacts of waste of natural resources on the environment. These include, among others, appropriate fertilisation practices, reduction of imbalances in phosphorus inputs and outputs to agricultural soils, recovery of phosphorus from sewage for fertilisation.

5.2.3 Ecosystem Services

Environmental factors

High nature value farmland (HNV) designation

Quantitative and descriptive

A HNV farmland is one where agriculture is a major land use and where it supports or is associated with either a high species and habitat diversity or the presence of European conservation concern or both[142]. HNV farmlands that have been abandoned run the risk of losing their biodiversity values because the traditional agricultural management on which specific biodiversity values relied for their subsistence has disappeared. The introduction of industrial crops on these types of abandoned lands may be an option to maintain the low intensity management and support biodiversity regrowth.

Farmland abandonment is an important cause for loss of HNV farmland and thus biodiversity in more marginal areas of Europe. The introduction of industrial crops in marginal lands needs to be tuned with the present biodiversity values.

To identify likely HNV farmland features, Member States would need to identify which features are of a high enough habitat quality to support the presence or likely reintroduction of species of conservation concern. This would be ascertained through the identification of selected species of European, and/or national, and/or regional conservation concern, which depend on the maintenance or continued existence of farmland features for their survival. For the species selected, a description would be provided of their relationship with, and dependence upon features in the agricultural landscape, with attention paid to the size, density and condition of the feature, and its spatial pattern in the landscape[143].

The HNV designation is used when a farmland either has ***1) a high proportion of semi-natural vegetation, 2) a mosaic of low intensity agriculture and natural and structural elements***, such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers etc., or ***3) is supporting species such as farmland birds and or farmland habitat linked to extensive farmland management.[144]***

Individual Rural Development Plans use methods suited to the prevailing bio-physical characteristics and farming systems.

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[142] Andersen, E., Baldock, D., Bennett, H., Beaufoy, G., Bignal, E., Brouwer, F., Elbersen, B., Eiden, G., Godeschalk, F., Jones, G., McCracken, D.I., Nieuwenhuizen, W., van Eupen, M., Hennekens, S. & Zervas, G., (2003) Developing a high nature value indicator. Report for the European Environment Agency, Copenhagen

[143] Institute for European Environmental Policy (2007) Final report for the study on HNV indicators for evaluation

[144] Paracchini, M. L., Petersen, J., Hoogeveen, Y., Bamps, C., Burfield, I., van Swaay, C. (2008) High Nature Value Farmland in Europe: An estimate of the distribution patterns on the basis of land cover and biodiversity data, *JRC Scientific and Technical Reports*

The HNV is calculated as a percentage (%) of the absolute area of Utilised Agricultural Area in hectares.

Soil quality, productivity and stability

Quantitative and qualitative

The primary indicator for assessing soil quality, productivity and stability is soil organic carbon, which can either increase or decrease depending on the agricultural management techniques that are put in place. Risk for losing soil organic carbon is associated with unsustainable harvest or removal levels of agricultural residue. Since determining sustainable yield level in conjunction with yearly soil organic carbon levels is complicated, the precautionary principle can be applied of allowing for maximum conservative removal rates established by experts. Other links to indicators include tillage practices, soil amendments such as biochar, mulching and manure inputs, residue management and rotation schemes.

Calculated as the (***1) the actual organic carbon content and (2) the organic carbon saturation relative to the maximum amount a soil is able to absorb in the given bioclimatic region, in Total Soil Organic Carbon (SOC) in arable land in megatonnes (Mt) or Mean SOC concentration in arable land: g/kg. The 3) C/N ratio is also relevant for determining organic matter.***

This indicator is also impacted by various agricultural management techniques mentioned above and can serve as complementary evidence to their success.
Indicative scoring:

--	High risk for losing soil organic carbon when growing and harvesting this type of biomass
-	
o	No relation to soil use / maintained soil organic carbon
+	
++	Growing and harvesting this type of biomass generally increases soil organic carbon.

Air quality

Quantitative/comparative to fossil fuel reference

Other than GHG emissions, air quality can be affected by either particulate matter or acidification. The former includes a mixture of solids and liquid droplets, either emitted directly or forming in the atmosphere when reacting with other pollutants. This sub-indicator can be quantified as life cycle PM10 emissions (g PM10/MJ outputs), in relation to the fossil reference. Small scale combustion of wood (logs) can have severe air quality impact (particulate emissions), especially for older stoves and open fires. Bigger installations generally have to fulfil stricter emission legislation, but this often depends on the national and local regulatory framework.

Acidification is another major contributor to air quality and is caused by acid-forming substances such as sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3).

This sub-indicator can be quantified as life cycle ***SO2-equivalent emissions (g SO2-eq/MJ outputs)***, in relation to the fossil reference.

Ammonia can be measured in ***kilotonnes per year***. It is linked to soil and water quality indicators since it increases the load of nitrogen in soils and waters. It can contribute to acid deposition and eutrophication, which in turn, can lead to potential changes occurring in soil and water quality. In Europe, A small fraction of NH_3 emissions result from the volatilisation of NH_3 from nitrogenous fertilisers and from fertilised crops.

Since acid deposition can result in an increase in impoverished soils and acidifying pollutants are removed from the atmosphere by dry deposition (direct uptake by vegetation and surfaces), marginal land improvement can act on both of these issues by remediating soils as well as providing additional vegetation to directly uptake air pollution.

Water quality

Quantitative/comparative to fossil fuel reference and qualitative

Potential impact of agricultural activities on water quality range from pollutants of pesticides to nitrates and phosphates. Sub-indicators include:

- Gross nitrogen balance: potential surplus of nitrogen on agricultural land (kg N/ha/year)
- Gross phosphorus balance: potential surplus of phosphorus on agricultural land (kg P/ha/year)
- Nitrate concentration in leaching water is expressed in mg NO_3 per litre.
- Phosphate concentration in water: mg P L^{-1}
- Biochemical oxygen demand (BOD)

Indicative qualitative scoring for either groundwater or surface water quality is the following:

--	Poor quality: concentration above hazardous level
-	Moderate quality: concentration above natural standard but still below hazardous level
+	High quality: concentration close to natural values or within the threshold indicated in the legislation for low-polluted water

Indicative quantitative scoring with actual concentration classes from CAP Impact Indicator on Water Quality is the following:

	Groundwater	Surface water
--	Poor quality: (">=50mg/l NO3")	Poor quality: (">=5.6 mg/l N and <11.3 mg/l N " + ">=11.3 mg/l N ")
-	Moderate quality: (">=25 mg/l NO3and <50 mg/l NO3")	Moderate quality: (">=2.0 mg/l N and <3.6 mg/l N " + ">=3.6 mg/l N and >5.6mg/l N ")
+	High quality: ("<10 mg/l NO3" + ">=10 mg/l NO3and <25 mg/l NO3")	High quality: ("<0.8 mg/l N " + ">=0.8 mg/l N and <2.0 mg/l N ")

Farmland bird index

Quantitative

This index is used as a general barometer of change for biodiversity on an agricultural landscape by measuring ***the rate of change in relative abundance of common bird species***. Such species are dependent on farmland for feeding and nesting and are not able to thrive in other habitats. Sites can follow guidelines from the European Bird Census Council for their Member State specifications, as well as conduct appropriate routine surveys of the bird population present on their farmland.

Sources for this indicator: Agro-environmental indicator (AEI): Population trends of farmland birds; Sustainable development indicators (SDI) –Biodiversity: Common Birds Index(Eurostat); SEBI indicator 01: abundance and distribution of selected species, which includes common farmland bird index (Pan-European Streamlining European Biodiversity Indicators (SEBI) initiative, EEA, DG ENV, etc.).

Crop residues left when simplified tillage techniques are used provide a habitat for arthropods, attracting more frequent visits by birds and a greater diversity. The presence of crop residues is considered the most important factor influencing the choice of nesting sites of ground nesting birds.

Baseline: Index with a base year of 2000 = 100

Invasive Species Index

Qualitative

Marginal lands are not only subject to invasive species as they are by definition degraded, fragilized ecosystems with the high potential of inviting rapacious species which rapidly colonise compromised areas. The following table can help characterise the extent of their spread in order to evaluate necessary intervention types. There is a ***link with the integrated pest management indicator*** since it offers several methods of controlling invasive weeds, plants or species.

High value farming, intercropping and agroforestry inputs can also contribute to reductions in invasive pests by producing native species or additional crops which can harbor natural predators.

	Definition	Interpretation	Extent
++	Not present in territory	Absent	**0**
+	Present in territory and either not established or with established populations that have not spread more than 10km from their source	Not or scarcely established	**1**
o	Established populations represent less than 10% of territory, with some having arrived from further than 10km from their source; or if more widespread then populations scattered and sparse	Established but still generally absent or at most occasional	**2**
-	Established populations present in 10% to 50% of the territory	Established and frequent in part of the territory	**3**
--	Established in more than 50% of the territory	Widespread	**4**

Delivering Alien Invasive Species Inventories Europe (DAISIE) contains continually updated information on biological invasions in Europe with available lists of species and their status per country (http://www.europe-aliens.org/default.do).

However, the ***choice of crop*** itself can represent an invasive threat for the region, thereby producing off-site effects to neighbouring areas by rapidly spreading after cultivation is established.

Weeds can also represent invasive species and are monitored by ***germination of weeds in number per m-2***.

Biodiversity rates

Quantitative

Biodiversity changes under marginal lands usage for growing industrial/non-food crops for biomass production can also be quantified in the following way:

- Earthworms diversity (number per species)
- Collembola (springtails) diversity (number per species)
- Parasitic fungi (m)
- Parasitic nematodes (number per species)

5.2.4 Smooth Operations of Business and Markets

Technical performance

Integration with industrial energy supply

Descriptive

This indicator addresses whether ***a system relies mainly on imports or if it can fully rely on domestic sources***, thus representing energy supply security. Indicator should assess whether the industry can be self-sustainable in producing diverse end-products from the rural industry.

Infrastructural accessibility

Descriptive

According to FAO-CGIAR land classifications, there is a higher probability for larger land degradation where there is higher population pressure and demand for land. Degraded marginal lands are more likely to occur in central locations rather than remoter ones, unless degradation occurs through land abandonment and encroachment of shrubs increasing chances for forest fires. Socio-economic limitations have a clear influence on the development opportunities of regions, particularly where they occur in combination with biophysical limitations. Furthermore, the more remote/decentral regions are located, the higher chance there is for abandonment of farmland with biophysical limitations. Remote location should be seen as an additional complicating factor for part of the marginal lands.

One sub-indicator is the designation of either a peri-urban, rural or deep-rural zone, based on the FARO project[145] which combines indicators on agricultural land use, accessibility, population and economic activity density.

Economic performance

Levelised life cycle costs

Quantitative

In terms of economics we should consider the ***levelised life cycle costs*** of the bio-energy carriers and biomaterials, in comparison to the reference (usually fossil counterpart), where possible distraction of subsidies or support systems should be made.

The outcome expressed in ***€/GJ or tonne of outputs*** is compared to the reference providing the same services (electricity, heat, transport fuels, products). Different compo-

[145] van Eupen, M., Metzger, M.J., Pérez-Soba, M., Verburg, P.H., van Doorn, A., Bunce,R.G.H., (2012) A rural typology for strategic European policies, Land Use Policy, 29, 473–48

nents of the costs are biomass processing, CAPEX (investment costs, for a certain annual capacity) and OPEX (operating costs) in terms of feedstock costs and other costs.

Net added value

Quantitative

The net added value is calculated by the ***market price minus the production costs per tonne of biomass.***

Productivity by ratio of crop yield to production costs

Quantitative

The productivity of land use for biomass products can be expressed in terms of ***available bioenergy carriers and biomaterials (or crop yield) per hectare*** of cultivated area, in dry mass and/or energy content (***tonne d.m. or GJ/ha/yr***.) and total production costs.

Production costs are comprised of weed controls, machinery, landscape management, pest management, drainage, irrigation, nutrient management, labour, infrastructural, and various others and is expressed in ***Euro ha-1yr-1***.

Crop yields and feedstock productivity depend on the cultivation system, input levels, bioclimatic conditions, and overall land suitability. Thus, a further differentiation is needed to account for land productivity categories (e.g. average land productivity in a certain region).

Processing efficiencies of biomass feedstocks into end products also need to be taken into account. For calculating the net productivity, by- and co-products along the full value chain need to be included.

Profitability relative to size of market, trade and investments

Quantitative

The ***profitability (gross and net profit) per ha, per tonne of raw material used,*** in relation to the total is an indicator used for the upstream section of the value chain.

Targeted markets of the products and services can range from small niche (e.g. specialised products) to very large worldwide markets. When focusing on small niche markets (e.g. specialised products), these markets may saturate quite fast, which complicates the roll-out of these technologies. In large worldwide markets (e.g. energy/fuels) there are more opportunities to find customers.

A sub-indicator of ***export potential and complementary industries*** can evaluate the potential of exporting the feedstock or biomaterial due to high market demand and the potential to support more than one industry. The ***market size*** to valorise outputs can be used: from a niche market (<1000 tonnes/year worldwide to worldwide market (~1 million tonnes/year worldwide) to a large worldwide market (>100 million tonnes/year worldwide).

Diversification of rural industry and enterprise

Descriptive

Diversified rural industry and enterprise can positively impact the economy of rural areas. Diversified value chains can induce more regional job creation, stimulate the rural economy, while other value chains may be more directed to large scale industry, often in the hands of international players/multinationals.

The re-allocation of some of a farm's productive resources, such as land, capital, etc., for new value-adding activities can reduce the risk of changing markets, consumer demand, government policy or climate change. Diversifying output can be an opportunity to exploit existing infrastructure, knowledge, human resources, and equipment.

The diversification indicator will be the assessment of ***a range of end product options*** for farmers in rural agricultural industry options and ***the economic viability of such diversification***. Economic analysis studies may lack for certain cases however similar cases can be used as a basis of comparison.

Socio-economic performance

Agricultural income compared to national average

Quantitative

What is the capacity of farmers to reimburse capital, pay for wages and rented land, and reward their own production factors? What is the level of policy support?

Agricultural factor income measures the remuneration of all factors of production (land, capital and labour) regardless of whether they are owned or borrowed/rented and represents all the value generated by a unit engaged in an agricultural production activity. It represents the net value added at factor costs.

Agricultural factor income = value of agricultural production – variable input costs – depreciation – total taxes + total subsidies

To compare to a national average, income per annual work unit (AWU) is used to correspond to one person occupying an agricultural holding (defined as a single unit both technically and economically operating under a single management to grow crops, for plant propagation or animal production) on a full-time basis. ***This index is available in: Eurostat Economic Accounts for Agriculture, Indicator A.***
Unit of measurement: EUR/AWU

Regional funding procedures and availability

Descriptive

Indicators can identify whether regional funding procedures are simple or complex, and their availability.

Role composition of regional actors

Descriptive

Indicators identifying whether regional actors involved represent all four corners of society or whether one is lacking between:

- ***researchers***: research institutes, universities, technology centres, technology platforms, agricultural students and EU projects
- ***farmers & landowners***: young farmers, foresters, land owners, associations, cooperatives, unions
- ***extension service providers & government***: agricultural chambers, ministries, regional government and authorities from sectors like agriculture, waste, circular economy, industry, rural development, EIP-AGRI, other thematic networks, operational groups
- ***businesses and industry representatives***: all bio-based industries including small and medium enterprises, and investors

Such multi actor initiatives are analysed based on the principles of the quadruple helix approach which beyond the 'triple helix' components of university, industry and government also recognises the important role of the society in the process of sustainable development of knowledge[146].

Awareness through social capital or community bonds

Qualitative and descriptive

Indicators assessing the level of awareness within a holding, community or industry can range from presence of non-governmental organisations which act as facilitators of local group formation, farmer field-schools which act as models for social learning and high level cooperation for sharing agro-ecological principles and farmer groups partnering with research institutions to help them become more responsive to local needs and create additional local value by working on technology generation and adaptation[147].

Awareness is also represented through social capital structures: such as norms, trust and bridging and bonding relationships[148]. These are complex to quantify, however they can be qualitatively assessed through processes of meetings, exchanges, and regular interaction which can happen at community events, social media platforms and partnerships.

--	Low social capital: low bonding or bridging social capital, low levels of combined trust, norms and network relationships, low representation of relevant stakeholders and very little legitimacy in partnership decision-making process
-	Average social capital: bonding but not bridging social capital, average levels of combined trust, norms and network relationships but only average representation relevant stakeholders and lacking complete diversity and political legitimacy in partnerships

[146] Carayannis E. G. and Campbell D. F. J. (2010) Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology, International Journal of Social Ecology and Sustainable Development 2010, 1(1):41–69

[147] Pretty, J. (2002) *Agri-Culture: Reconnecting People, Land and Nature*, Earthscan

[148] Pretty, J. N. (2003) Social Capital and the Collective Management of Resources, Science, 302(5652): 1912-1914

+	High social capital: bonding and bridging social capital, high levels of combined trust, norms and network relationships, high degree of representation of relevant stakeholders, and procedural and political legitimacy in partnership decision-making process

5.2.5 Job Opportunities

Socio-economic measurement

Agricultural employment structure

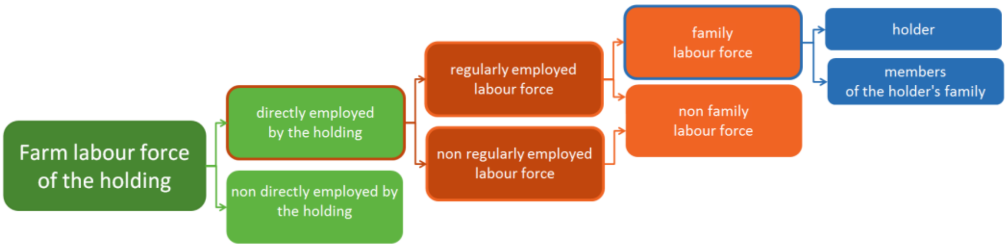
Quantitative and descriptive

The employment structure can be analysed in terms of its share of workforce at risk of poverty or social exclusion in thinly populated areas, its share of skilled versus unskilled employees, male versus female, and age groups.

Eurostat baseline: 75% of the population aged 20-64 should be employed

The sub-indicator of skilled versus unskilled can combine different titles such as experts or agronomists, and components such as wage and labour costs.

Additionally, according to Eurostat[149], farm labour force can be broken down into direct or indirect employment, regular or non-regular, family or non-family, and holder or family member:



Employment footprint by direct job equivalents

Quantitative and comparative to fossil fuel reference

Net job creation as a result of the deployment of biomass should be regarded over the full value chain. This can be expressed in ***number of full-time jobs per GJ or tonne of biomass or end products***. The indicator can be disaggregated into skilled vs unskilled jobs, permanent vs temporary jobs or local vs global job creation.

There is possibility to add full ***regional*** direct job equivalents where the biomass is being promoted. This indicator can tie in with other socio-economic indicators. It is expressed in ***number of regional full-time jobs/tonne or GJ of end products (yearly)***.

[149] (Source: Eurostat Statistics Explained, Glossary: Farm labour force, https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Farm_labour_force, last modified on 4 October 2018, at 16:13, accessed on 23rd November 2018)

6. Baseline indicators for biophysical constraints

Table 3 Baseline indicators for biophysical constraints

Biophysical constraint	Indicator	Threshold
Excess soil moisture (Soil related)	Number of days at or above Field capacity	230 days
Limited soil drainage (Soil related)	Areas which are water logged for significant duration of the year	Wet within 80cm from the surface for over 6 months, or wet within 40cm for over 11 months OR Poorly or very poorly drained soil OR Gleyic colour pattern within 40cm from the surface
Adverse chemical composition of soil (Soil related)	Presence of salts, exchangeable sodium, excessive acidity Natural toxicity/toxicity by pollutants?	Salinity: lower/equal to 4 deci-Siemens per meter (dS/m) in topsoil OR Sodicity: ³ 6 Exchangeable Sodium Percentage (ESP) in half or more (cumulatively) of the 100cm soil surface layer OR Soil Acidity: pH ≤ 5 (in water) in topsoil
Low fertility of soil (Soil & Crop related)	Soil reaction (pH) Soil organic carbon	Soils with pH below 4.5 or pH above 8 (at depth 0-30 cm SOC % average of depth range 0-30 cm at <0.5% (<0.75% = sub-severe
Unfavourable soil texture and stoniness (Soil & Crop related)	Relative abundance of clay, silt, sand, organic matter (weight %) and coarse material (volumetric %) fractions	15% of topsoil volume is coarse material, including rock outcrop, boulder OR Texture class in half or more (cumulatively) of the 100 cm soil surface is sand, loamy sand defined as: silt% + (2 x clay%) 30% OR Topsoil texture class is heavy clay (³ 60% clay) OR Organic soil (organic matter ³30%) of at least 40cm OR Topsoil contains 30% or more clay and there are vertical properties within 100cm of the soil surface
Shallow rooting depth (Soil & Crop related)	Depth (cm) from soil surface to coherent hard rock or hard pan.	≤ 30cm
Steep slope (Soil related)	Change of elevation with respect to planimetric distance (%).	³ 15%

Low temperature (Climate related)	Length of Growing Period (number of days) defined by number of days with daily average temperature > 5°C (LGPt5) OR	≤ 180 days
Dryness (Climate related)	Ratio of the annual precipitation (P) to the annual potential evapotranspiration (PET)	Threshold: P/PET £ 0.5

7. Conclusions & future work

This first report for Good Practices describes the aim, rationale and definitions for the ongoing research and provides an initial mapping of selected cases that will be further analysed through modelling and participatory approaches. The number of cases will be increased to ensure all agro-climatic zones, marginality factors and crop types under research in MAGIC are included.

The report also provides structured and detailed descriptions of indicators that will be used for the analysis during the second and third year of the project within Tasks 7.2 and 7.3.

Annex I Survey questionnaire used to categorise 'good practices' for industrial crops grown on marginal lands

Q1. Please provide us with example of a region and/or cluster that contains one or more best practices and contact details. *(In our analysis, best practice means region that contains one or more successful projects with industrial crops grown on marginal land)*

- Example of the successful project/best practice:
- Contact Person:
- Region:
- Country:
- Size of the land cultivated with industrial crops:

  (≤50; 50-100; 100-500; 500-1,000; ≥1,000; other) in hectares
- Industrial crops grown:
- Start date of the project (mm/yy):
- End date of the project (mm/yy):
- Total Cost of the Project in Euro:
  - European Union fund:
  - National Public:
  - National Private:
- Which fund (public and/or private) supported the project?

  European Regional Development Fund

  CAP (Green Payments)

  European Social Fund

  Instrument for Pre-Accession Assistance (IPA)

  Other (please explain)

The analysis in this section will provide a thorough outlook of the key assets characterising the best practices. The key assets are grouped in biophysical, economic, environmental and social categories. Which of the marginality factors apply to your region and how would you rate their marginality level from high, medium to low?

Q2. Marginality based on Biophysical characteristics:

Biophysical assets	Criteria	Marginality level (High, Medium, Low)
Soil	Limitation in rooting	
	Low fertility	
	Adverse chemical composition	
Climate & Soil	Excessive wetness	
Climate	Adverse climate	
Terrain	Adverse terrain	

Q6. Marginality based on Economic characteristics:

Economic assets	Criteria	Marginality level (**H**igh, **M**edium, **L**ow)
Rent	Land rent	
Productivity	Yields	
Funding	Private funds; Public funds	
Accessibility	Infrastructure	

Q7. Marginality based on Environmental Characteristics:

Environmental assets	Criteria	Marginality level (**H**igh, **M**edium, **L**ow)
Resource Use	Biodiversity and conservation	
	Land Use	
Water Quality	Water Availability	
	Water use efficiency	
Soil Quality	Organic content and nutrient balance	
	Erosion	
Climate Change	GHG reduction	
	GHG emission related to iLUC	

Q8. Marginality based on Social/Institutional Characteristics:

Social/ institutional assets	Criteria	Marginality level (**H**igh, **M**edium, **L**ow)
Socio-economic	Accessibility	
	Infrastructure	
Policy	Presence of policy instruments	
	Effectiveness of policy instruments	
	Consistency of policy	
	Monitoring procedures	
Social	Population age	
	Culture	
	Awareness	