Task 3.4 Monitoring of social impacts

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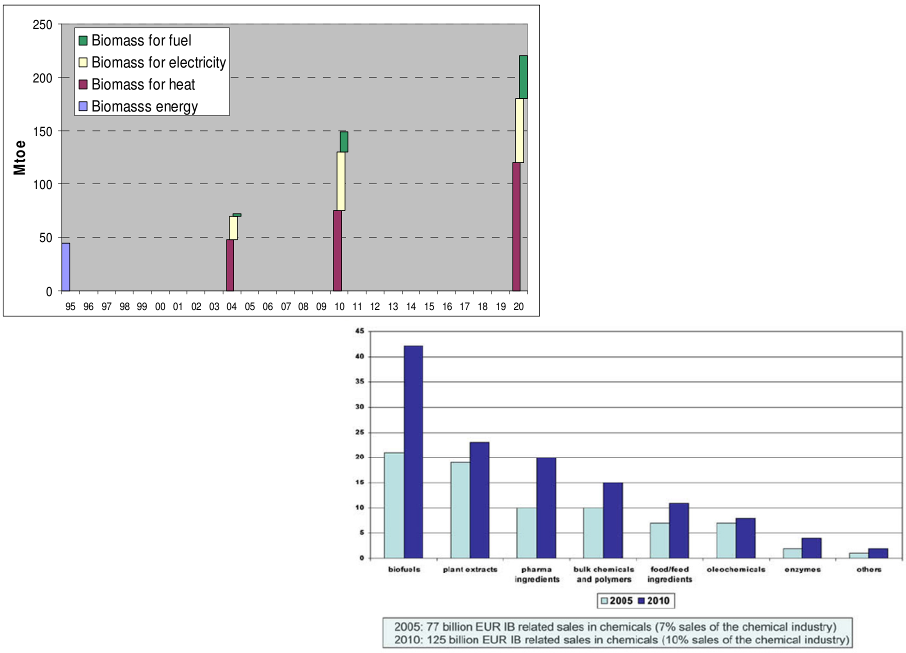
Contents

The context

Policies that aim to tackle climate change and increase security of energy supply coupled with industrial initiatives for bio- feedstocks has led to significantly increased demand for raw materials and conflicts have already risen between sectors, particularly food.

As the debate evolves, the stakeholders seek optimal solutions for future cropping in terms of minimal impacts on land and water use, increased investment opportunities and job creation, and overall improved social welfare.



Source:DG Research, Europabio

Figure 1. Demand for biofuels and bio-materials

4F crops (food, feed, fibre and fuel) is a concept recently introduced as potential outlet to the restructure of European agriculture aiming to provide opportunities for crop and market diversification, job creation in rural areas as well as farm income improvements through multiple end product uses[1] [2] [3].

However, a focused evaluation of their qualitative profiles under key economic, environmental and socio- economic factors is lacking.

[1] Bassam, N. E., 1998. "Energy Plant Species", James & James (Science Publishers) Ltd.

[2] Monti, A., Fazio, S., Lychnaras, V., Soldatos, P. and G. Venturi, 2007. "A full economic analysis of switchgrass under different scenarios in Italy estimated by BEE model", *Biomass and Bioenergy*, Vol. 31, N. 4, pp. 177-185, April 2007.

[3] Soldatos, P., Lychnaras, V., Asimakis, D and M. Christou, 2004. "Bee - Biomass Economic Evaluation: A Model for the Economic Analysis of Biomass Cultivation", 2nd World Conference and Technology Exhibition on Biomass for Energy, Industry and Climate Protection, 10-14 May 2004, Rome, Italy.

Socio-economic impacts for 4F crops

The introduction of 4F cropping systems can provide new opportunities for the EU agricultural sector in terms of land use, job maintenance, support of rural industries and new investments in supporting sectors such as machinery and fertilisers.

To date, analyses have focused mainly on estimating costs and environmental impacts of new crop systems by examining supply chains and comparing them with current ones.

The aim of this work is to complement the research work performed within the framework of the EU project KBBE-212811: Crops for Food, Feed, Fiber and Fuel - 4F Crops. Two aspects are analysed for a selected number of representative crops and countries with good potential for their cultivation, i.e.:

- Their qualitative performance under a set of defined economic, environmental and socio-economic factors.
- A quantitative analysis regarding the generated income and the potentials jobs (created/ maintained) directly or indirectly.

The information and data are based on recent literature as well as on the input from the research work undertaken in the other work packages of the project.

For the purposes of this study, the socioeconomic impacts of crop production and management will be linked to the economic and environmental aspects concerning land, water, energy and other inputs. The analysis will take into account the relationship and interactions among economic, environmental and socioeconomic impacts within a supply chain.

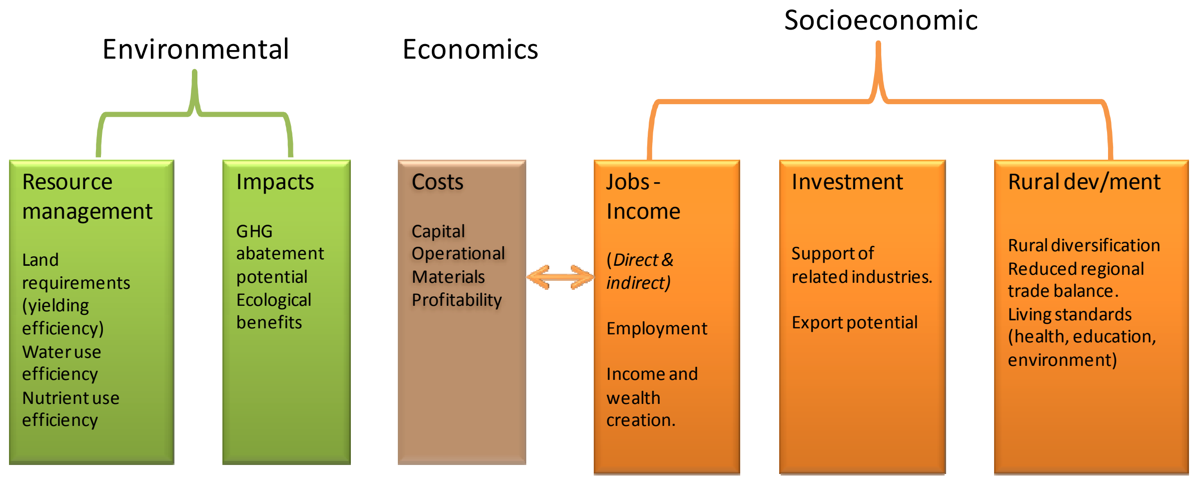


Figure 2. Key environmental & economic aspects associated with the analysis of socioeconomics.

Methodology

The top-down methodology consists of three inter-linked steps:

- Crop matrix analysis. Selected crop options and the main markets they address.
- Qualitative analysis. This is based on key economic, environmental and socio-economic factors.
- Quantitative analysis. Based on the information provided in the cost appraisal of the different crop options (Tasks 3.2 & 3.3), a structured analysis is undertaken is this report to define the income and the number of jobs generated by the production of the crops in each country. Case studies are aligned with the work in the work package and data is drawn from related work packages. To estimate income and jobs (direct & indirect) the BIOSEM model has been used- only for the crop production stage).

Figure 3 below presents an overview of the approach followed in the report.

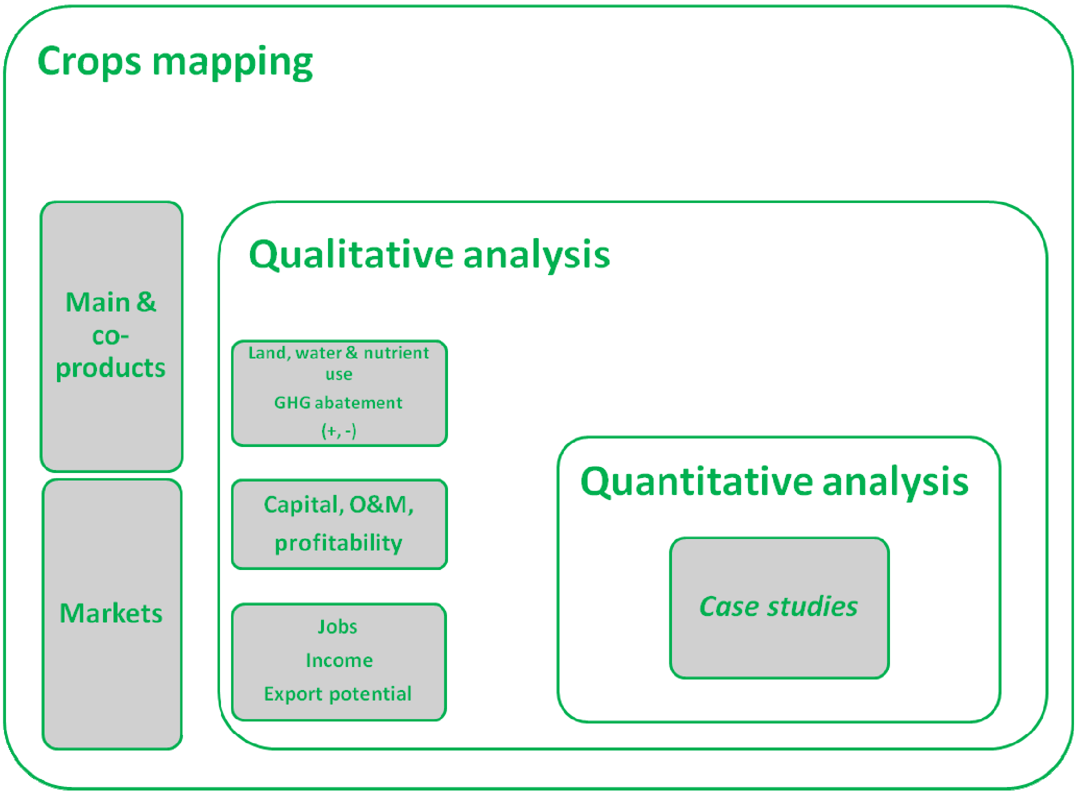


Figure 3. Schematic representation of methodological approach.

Crops & markets

A matrix is developed with the most important crops within EU27 and the related end product markets.

The crop range covers both current and future options (2010 -2030). Main and secondary stream products will be clearly defined for each crop based on current uses and future projections as identified by recent literature.

Qualitative analysis

A set of qualitative factors is used in the analysis to assess the socioeconomic impacts of the selected 4F crops.

Table 1. Key Factors

Economic[4]	
Capital intensive	Perennial crops, especially the ones established with rhizomes & cuttings have substantially higher costs than annual ones but also than other perennials which are established with seeds.
Operational & Materials	Include materials (seed/stem cuttings for crop establishment, fertilisers and pesticides for increased production, irrigation water, etc.) as well as labour and energy for the respective practices
Profitability	The crop profitability (gross & net profit) per hectare in relation to the total production costs.
Environmental[5], [6]	
Land requirements (yielding efficiency)	The land required to produce 1 tonne of feedstock.
Water use efficiency	Water use efficiency is closely related to environmental resource management. Here, it is considered as the efficiency of the crops to turn the given amount water into biomass.
Nutrient use efficiency	Similarly to water use efficiency the efficiency of crops to grow and produce useful material with optimal nutrient use is an important element in the environmental resource management.
GHG abatement potential[7]	The potential of the under study crops to improve GHG balances on a full chain analysis.
Ecological benefits	These refer to the overall benefit of the crops to the ecosystem taking into account biodiversity, wildlife habitat, visual amenity, etc.
Socio-economic	
Employment (jobs/ha)	The number of jobs that can be created/ maintained by the production of 1 tonne of feedstock.
Income	The income generated by the production of 1 tonne of feedstock & the cultivation of 1 ha.
Support of complementary industries	The potential of supporting more than one industry (food & fuel, etc.) from one crop.
Export potential	The potential of exporting the produced feedstock due to high market demand.
Rural diversification	In the agricultural context, diversification can be regarded as the re-allocation of some of a farm's productive resources, such as land, capital, farm equipment and paid labour, into new activities. These can be new crops & value-adding activities. Factors leading to decisions to diversify are many, but include; reducing risk, responding to changing consumer demands or changing government policy, responding to external shocks and, more recently, as a consequence of climate change. Adapted from: http://en.wikipedia.org/ . In this analysis, it is considered as the potential of the crops to provide new outlets to farmers either by changing current crops or by adding new ones to their portfolio thus exploit their infrastructure (irrigation systems, etc.), human resources (labour) and equipment with crops that are complementary to the ones they already have in timing of cultivation practices.

[4] Soldatos P, Lychnaras V, Panoutsou and Cosentino SL, Economic viability of energy crops in the EU: the farmer's point of view. *Biofuels Bioprod Bioref* **4**:637–657 (2010).

[5] Rowe RL, Street NR and Taylor G, Identifying potential environmental impacts of large-scale deployment of dedicated bioenergy crops in the UK. *Renew Sust Energ Rev* **13**:271–290 (2009).

[6] Zegada-Lizarazu W, Elbersen W, Cosentino SL, Zatta A, Alexopoulou E, Monti A, Agronomic aspects of future energy crops i n Europe. *Biofuels Bioprod Bioref* **4**:674–691(2010).

[7] Fernando AN, Duarte MP, Almeida J, Boléo S and Mendes B, Environmental impact assessment of energy crops cultivation in Europe. *Biofuels Bioprod Bioref* **4**:594–604 (2010).

They are classified in economic, environmental and socio- economic. Table 1 above provides a detailed description for each of them.

The first two categories will act as 'showstoppers' for the quantitative analysis since high costs, low profitability as well as negative impacts on land , water use and GHG balances highly restrict the value of a potential crop.

Following, the income and job opportunities will show which crops have higher economic value in terms of cash brought in a region/ sector and subsequent job creation/ maintenance. Finally, the rural diversification will act as further drivers or constraints to the potential integration of these crops in the agricultural systems.

Table 2. Qualitative indicators for 4F crops

Key factors	Crop 1	Crop 2	Crop 3
Economic			
Capital intensive			
Operational & Materials			
Profitability			
Environmental			
Land requirements (yielding efficiency)			
Water use efficiency			
Nutrient use efficiency			
GHG abatement potential			
Ecological benefits			
Socio- economic			
Employment (jobs/ha)			
Income			
Support of complementary industries			
Export potential			
Rural diversification			

The range of the values for each crop within the individual indicator category will be:

VP: very positive

P: positive

N: negative

VN: very negative

Quantitative analysis

As a complement to the qualitative analysis a socioeconomic model is been used to provide evidence on the costs, number of jobs and income generation potential.

BIOSEM approach

In the framework of this research work, the selected crop production chains were evaluated in terms of socio-economic viability, using the principles of the BIOSEM technique[8].

The BIOSEM technique was developed through a two-year project, which started in January 1997 under the FAIR Programme of DG IVI under the European Commission's Fourth Framework Programme. The objective was to construct a quantitative economic model to capture the income and employment effects arising from the deployment of bioenergy plants in rural communities.

The methodological approach of BIOSEM (FAIR Programme. 1996a) starts with the investment appraisal, evaluating the economic viability of the crop production chains and then proceeds to the evaluation of certain socio-economic benefits (income and jobs). The investment appraisal is necessary to ensure that the resources used on the crop production, are allocated correctly.

This gives the farmer a quick assessment of whether biomass crop production can be a realistic alternative income source.

In this report, the model was moderated to estimate the jobs created and the generated income and the jobs (direct & indirect) per ha of cultivated land for each of the crops. The analysis was performed only for the crop production stage. No storage or transportation is included as this would need fully defined supply chains to the satge of end products and it was out of the scope of this work.

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[8] Madlener, R. And H. Myles. 2000. Modelling Socio-Economic Aspects of Bioenergy Systems: A survey prepared for IEA Bioenergy Task 29.

Crops & Markets

Crops

The crops analysed in this study can be categorised in oil, sugar, starch and lignocellulosic ones. Detailed information for their main agronomic aspects is presented in Table 3 below.

Table 3. Agronomic aspects of selected energy crops under study in Europe.

Species	Sowing/ establishment	Harvest	Yield (t/ha)	Remarks
Oil crops				
Rapeseed	March- May	June-July	3-5 (grain)	Both annual (spring-sown) and biennial (winter-sown) types of *Brassica napus* ssp. *oleifera* are cultivated. Winter crops can be harvested from late July, spring ones usually ripening during September;
Sugar crops				
Sweet sorghum	March- May	Sept-Nov	16-35 (fresh stems)	C4 annual grass with a well-developed root system and robust aerial parts, which are usually supported by prop roots. Growth characteristics are very variable, depending upon the type; some varieties may exceed 4 m in height, while others may attain 50 cm.
Sugarbeet			14-20	Annual crop requires good-quality land. High productivity and also higher emission levels of agrichemicals. Deployment in the UK, Germany and other member states for bioethanol production.
Starch crops				
Wheat	March- May	June-July	2,5-9 (grain)	Wheat and barley are annual grasses 60 - 120cm tall. Varieties have been traditionally bred for starch and straw has been used for feeding and bedding purposes. Recently both crops are used as feedstocks for bioethanol production in Europe and worldwide.
Maize	March- May	June-July	10-15 (grain)	Corn is recently used as a bioethanol feedstock with specific varieties being bred for this purpose.
Lignocellulosic				
Hemp	April - May	July-August	12- 22	Hemp (Cannabis sativa L.) is well-known for its industrial and textile applications (e.g. insulation materials, weed suppression matting, paper, particle board, and car interior panels).
Cardoon	Feb- March or Sept- Oct	July-Sept	10-22	Low input, high biomass yielding crop, well adapted to the semi-arid Mediterranean climatic conditions. due to its winter growth and to its robust rooting system, it offers protection against soil erosion in sloping and marginal lands.
Miscanthus	March- June	Feb-April	2-24	Perennial C4-crop that is harvested each year. So far, only limited commercial experience in Europe. Breeding potential hardly explored.
Giant reed	March- May	Feb-April	12-24	C3 perennial crop, native to the Mediterranean region. Tolerant to various soil types with high productivity under irrigation. It abundant root system provides tolerance to drought conditions, efficient water uptake and protection to soil erosion.
Switchgrass	April- May	Feb-April	10-20	Perennial C4-crop that is harvested each year. It is a cool-season grass and does best on moderately deep to deep, somewhat dry to poorly drained, sandy to clay loam soils. It does poorly on heavy soils.
Willow	March- April	Nov-Dec	8-20	Perennial crop with typical rotation of some 3–4 years. Suited for colder and wetter climates. Commercial experience gained in Sweden and to a lesser extent in the UK and some other countries.
Poplar	March- April	Nov-Dec	8-18	Perennial C3-crop, currently especially planted for pulpwood production in various countries. Current typical rotation times 3-4 for coppice systems or 8–10 years for single stem systems.

Source: adapted from Panoutsou, 2010.[9]

[9] Panoutsou, C. 2010. Supply of solid biofuels: potential feedstocks, cost and sustainability issues in EU27. In: "Solid Biofuels for Energy: A Lower Greenhouse Gas Alternative", ed. Springer 2010, ISBN 978-1-84996-392-3, 258 pp.

Markets

A matrix is developed with the important crops for food, feed, fibre & fuel within EU27 and the related end product markets. The crop range covers both current and future options (2010 -2030). Main and secondary stream products are presented for each crop based on current uses and future projections as identified by recent literature.

Table 4 presents a matrix of the different crops, their markets and main products.

Table 4. Crop products (main & co- products) and markets

Crop type	**Market (Food, Feed, Fibre, Fuel)**				**Main product**
	Food	Feed	Fibre	Fuel	
Sugar					
Sugarbeet	√	√		√	sugar
Sweet sorghum		√		√	ethanol
Starch					
Maize	√	√		√	flour
Wheat	√			√	flour
Oil					
Rapeseed	√	√		√	oil
Lignocellulosic					
Cardoon		√	√	√	biomass
Miscanthus			√	√	biomass
Switchgrass			√	√	biomass
Giant reed			√	√	biomass
Poplar			√	√	biomass
Willow			√	√	biomass
Eucalypt			√	√	biomass
Hemp			√	√	fiber

Qualitative analysis

A set of qualitative key factors is used in the analysis to assess the socioeconomic impacts of the selected 4F crops. This is developed for the three impact categories analysed in the project, i.e. economic, environmental and socioeconomic.

The two first categories, economic and environmental act as 'stopper' since high capital & low profitability along low scores on land, water and nutrient use are considered to restrict the value of a potential crop.

Table 5. Qualitative profile for selected 4F crops

Key factors	Wheat	Maize	Sugarbeet	Rapeseed	S. sorghum	Hemp	Cardoon	Miscanthus	Switchgrass	G. reed	Poplar	Willow	Eucalypt
Economic													
Capital intensive	P	P	P	VP	P	P	VP	VN	VP	VN	VN	VN	VN
Operational & Materials	P	P	P	P	P	P	P	P	P	P	P	P	P
Profitability	N	VP	VP	N	P	P	VP	VP	VP	VP	P	P	P
Environmental													
Land requirements (yielding efficiency)	N	VP	VP	VN	VP	P	VP	VP	VP	VP	P	P	P
Water use efficiency	P	VP	P	P	VP	P	VP	VP	VP	P	N	P	P
Nutrient use efficiency	P	VP	P	P	VP	P	VP	P	VP	P	P	VP	VP
GHG abatement potential	N	P	VP	VN	P	P	VP	VP	VP	VP	VP	VP	VP
Ecological benefits	O	O	O	O	P	O	VP	VP	VP	N	P	P	P
Socioeconomic													
Employment (jobs/ha)	O	O	P	O	VP	P	VP	VP	VP	VP	VP	VP	VP
Income	P	P	VP	P	VP	P	VP	VP	VP	VP	P	P	P
Support of complementary industries	P	VP	P	P	P	P	VP	VP	P	O	O	O	O
Export potential	P	P	N	VP	N	P	VP	VP	VP	VP	VP	VP	VP
Rural diversification	P	P	P	P	P	P	P	P	P	P	P	P	P

VP (3): very positive
P (1): positive
O (0): Neutral
N (-1): negative
VN (-3): very negative

Final crop selection is based on their total score presented in Table 5 and illustrated in Figure 4. Only crops with a total score above 20 points will be considered in the case study quantitative analysis. These are by descending order of scoring:

- Cardoon
- Switchgrass
- Miscanthus
- Sweet sorghum, and
- Maize

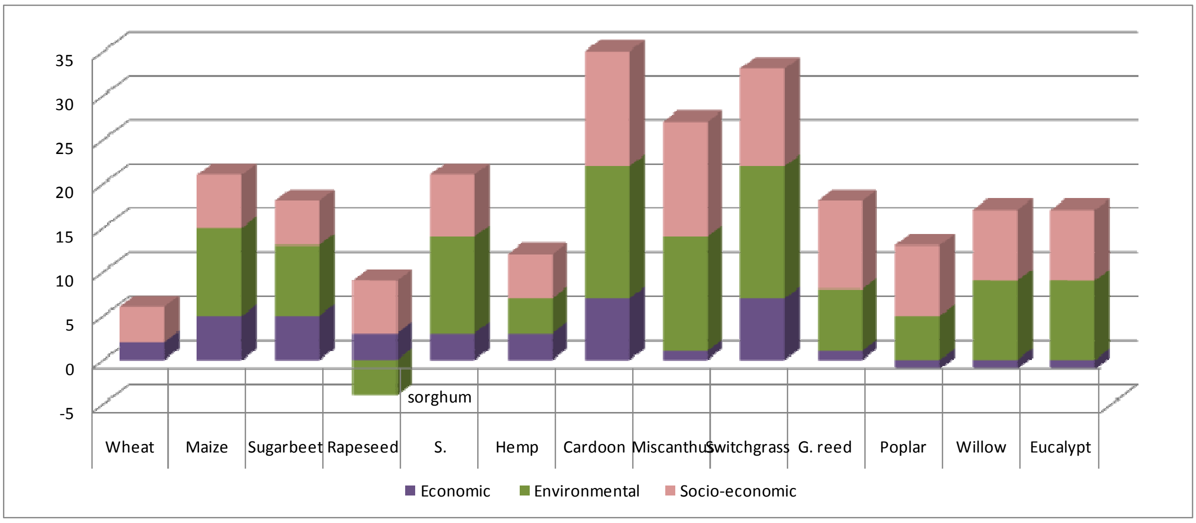

Figure 4. Performance under economic, environmental and socio-economic factors for the selected crops

Cardoon, switchgrass and miscanthus show the highest overall score. These crops share several favourable characteristics. These are all perennial grasses that are high yielding while efficient in terms of land, water and nutrient use. Moreover, their production is close to traditional food crops, so farmers can make use of existing machinery and techniques. All these species show high levels of resistance to pests and diseases. These various factors combine to make economic performance relatively good.

Cardoon and switchgrass are both established from seed, which is relatively straightforward. Miscanthus is established from rhizomes, which is more capital and labour intensive.

These crops can also be used across a wide geographic area with the exception of cardoon that is not suited for northern Europe. These crops have suitability to marginal and erosive lands and they also carry low risks of invasion into surrounding lands, particularly in the case of miscanthus which is a sterile clone.

At the other end of the spectrum, the two food crops wheat and rapeseed have low scores. Both species uses a less efficient photosynthetic. These crops both require high water and nutrient input. These are sensitive to pests and diseases, so require high inputs of pesticides. They are also out-competed by weed species, so require high inputs of herbicide. Their yield in terms of biomass is relatively low. Consequently, economic performance is poor. Also, greenhouse gas balance (especially for the 'biofuel' option) for both crops is rather low.

Giant reed is a highly invasive plant, and many farmers will consider this an important risk. This crop also requires considerable quantities of water. Nonetheless, yield potential is high.

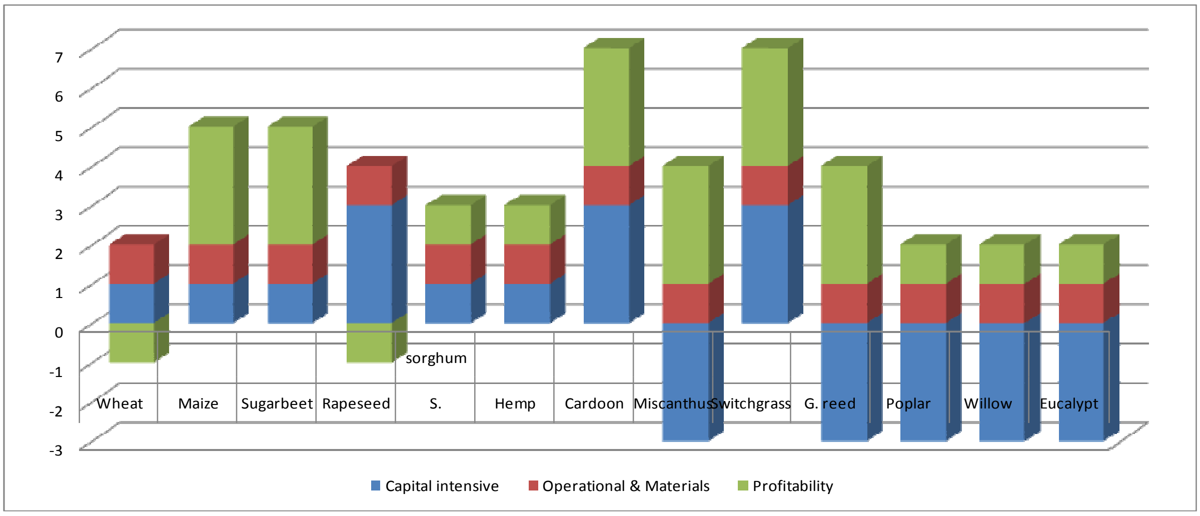

Figure 5. Performance under different economic factors for the selected crops

Hemp is well-known for its industrial and textile applications (e.g. insulation materials, weed suppression matting, paper, particle board, and car interior panels). Its use as an energy crop, however, is relatively new and requires harvesting the whole plant.

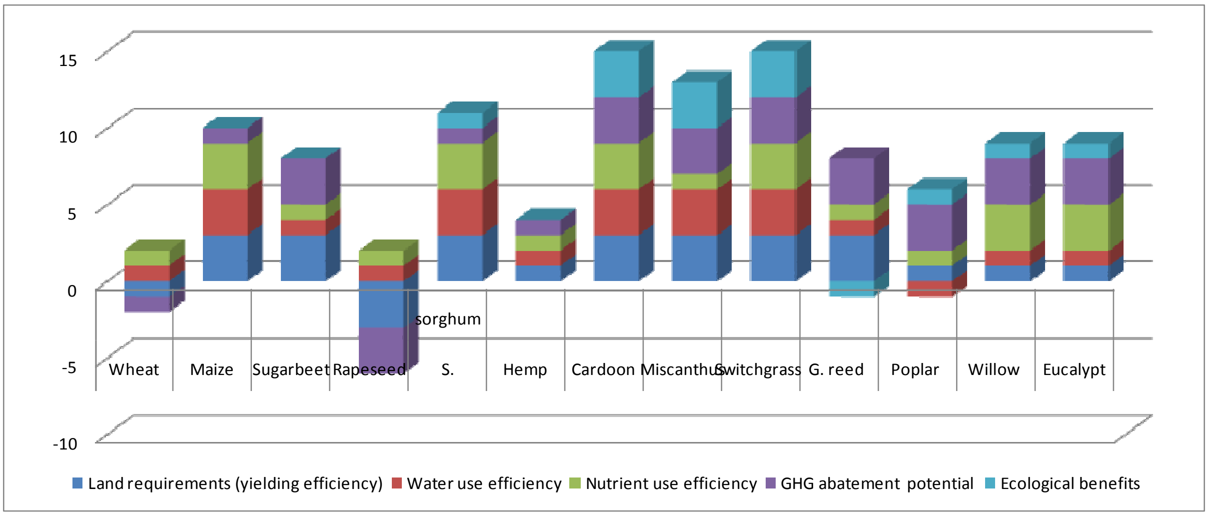

Figure 6. Performance under different environmental factors for the selected crops

In view of a more economic second-generation feedstock for ethanol production, hemp could take a leading role because of its high cellulose content. Hemp can be grown in a wide range of environmental conditions (from northern to southern Europe).

Sweet sorghum is an annual crop. It is also includes various novel features for producers. These factors combine to make costs of production rather high. The susceptibility of the crop to low temperatures restricts its use to southern Europe. However, its high yielding potential makes it an important candidate for future ‘bioethanol’ feedstocks.

Hemp and sweet sorghum are annuals and therefore may fit well into crop rotations where they may serve to control weeds, diseases, and pests. Moreover, the deep root systems of both crops favour a more complete and deeper use of soil resources improving the overall efficiency of a cropping system.

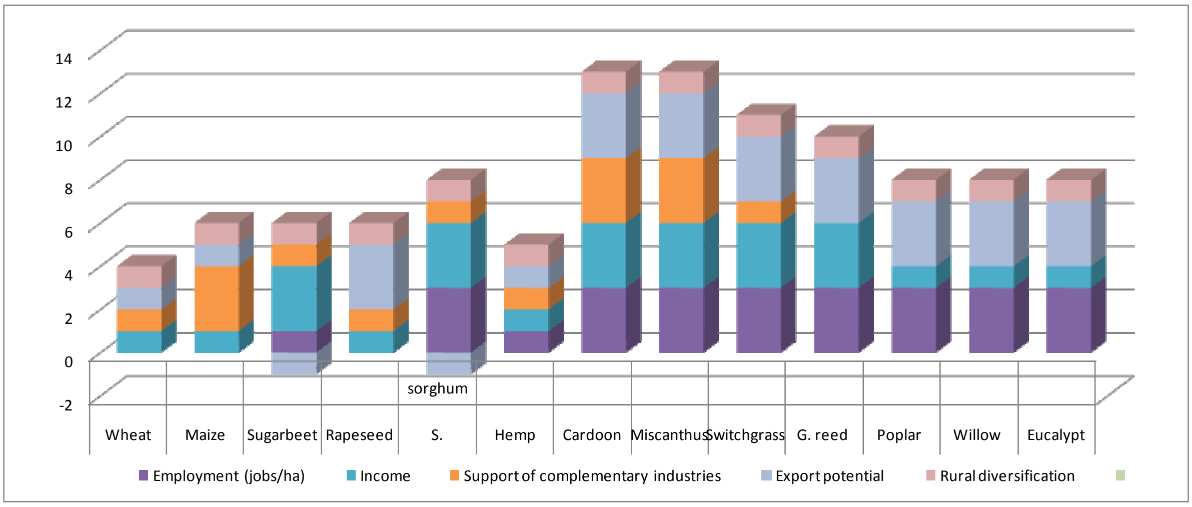

Figure 7. Performance under different socio- economic factors for the selected crops

Most crops offer the opportunity to be stored for extended periods of time (in or close to the farmer field perhaps) and / or transport over long distances including from one country to another.

However, sweet sorghum and sugarbeet both need to be processed rapidly following harvest. Failure to do so leads to sugar fermentation and reduction in quality for their end use market namely liquid biofuels. These crops are therefore restricted to localised production and processing.

Quantitative analysis

Following the qualitative part of the analysis presented in this report, a quantitative evaluation in terms of income and jobs is presented in this section for sweet sorghum, maize, cardoon, switchgrass and miscanthus.

The analysis was performed in a selected number of countries where the aforementioned crops have good adaptability and yielding potential.

The quantitative analysis was conducted using BIOSEM model for the selected crops in each country. Cost figures are based on information from Tasks 3.2 & 3.3 and adapted accordingly.

Case studies

A selected number of case studies has been undertaken to define the potential of the crops to generate income and jobs and compare the values among different European regions & crop production systems (low & high).

The case studies take into account the financial position of selected crops in various European regions and the estimated costs under different cultivation regimes as they have been addressed within Task 3.3.

The selected energy crops belong to different groups starch, sugar lingo and among other products can contribute to the production of biofuels (first & second generation bioethanol) as well as support stationary applications for heat & power.

Although sweet sorghum is not yet commercially exploited, it appears today as one of the most promising future crops for the production of ethanol, because it gives high fuel per hectare ratio (about 8000 l/ha), it grows in a very wide range of climates, it is resistant to long periods of drought, and it gives high yields of biomass for ethanol production.

Maize is one of the most widespread crops in Europe, well known for a long time. Its use as energy crop for the production of ethanol has increased the demand for land and has driven selling prices up. At the same time questions have been raised regarding the competition between their use for food or for fuel.

Cardoon represents a good case for south European lands and can be cultivated both as irrigated and rained. In this report data are presented for the irrigated option. It is regarded as multi purpose crop and can support, except the energy, the feed and fiber markets as well.

Switchgrass and Miscanthus are typical C4 warm season perennial grasses, with a wide range of climatic adaptability and best fitted to central and southern Europe. The establishment of switchgrass by seeds (about 4–10 kg ha–1 depending on seed size, dormancy, etc.) is relatively cheap and easy in comparison to Miscanthus x giganteus which is usually propagated by rhizomes or by in vitro culture and thus more capital intensive.

Table 6 summarizes the cases analyzed in this report. The data sources are statistics from FAO and Eurostat, related articles and other publications, related research programs, etc. Specific references are given in various parts of the report.

The case studies represent the production and other agronomic characteristics of the climatic zone which each case study represents, but the both the financial data, costs and income/ jobs (land rent, labor cost, etc.) depend upon the country of the case study.

Table 6 List of case studies in the selected Member States

	Crop	Climatic Zone	Country	Land	Input
1	Sweet Sorghum	MDN	Italy	Marginal Agricultural	Low High
2	Sweet Sorghum*	MDN	Greece	Agricultural Agricultural	Low High
3	Maize	ATC	Germany	Marginal Agricultural	Low High
4	Maize	ATC	France	Marginal Agricultural	Low High
5	Maize	MDN	Italy	Marginal Agricultural	Low High
6	Maize*	MDN	Greece	Marginal Agricultural	Low High
7	Cardoon*	MDN	Italy	Marginal Agricultural*	Low High
8	Cardoon*	MDN	Greece	Agricultural Agricultural*	Low High
9	Miscanthus	MDS	Greece	Marginal Agricultural*	Low High
10	Miscanthus	ATC	Germany	Marginal Agricultural	Low High
11	Miscanthus	ATC	France	Marginal Agricultural	Low High
12	Miscanthus	CON	Italy	Marginal Agricultural	Low High
13	Switchgrass	CON	France	Marginal Agricultural	Low High
14	Switchgrass	MDN	Italy	Marginal Agricultural	Low High
15	Switchgrass	MDN	Greece	Marginal Agricultural*	Low High

ATC: Atlantic Central, CON: Continental, MDN: Mediterranean North, MDS: Mediterranean South
** Irrigated*

Cost data for income were based on the analysis performed within WP3 for Tasks 3.2 & 3.3, and adapted accordingly. Key figures are presented in Tables 7 & 8 below.

The figures presented reflect the average country values for each crop and are based on crop cultivation in medium fertility land. Irrigation is included in the analysis fro maize and sweet sorghum in Greece as well as cardoon both in Italy and Greece.

Table 7. Total production costs for the selected crops per country[10]

	Sweet sorghum	Maize	Cardoon (irrigated)	Switchgrass	Miscanthus
Cost per ha (€)					
France	950	**1.479**		848	**1.024**
Germany		1.179		870	694
Italy	650	**1.738**	**650**	896	**1.299**
Greece	1.200	1.000	800	847	1.150
Yield per ha (tonnes) [11]					
France	80	8		12	16
Germany		9		12	15
Italy	85	9	18	**15**	14
Greece	70	12	18	15	20
Cost per tonne (€)					
France	12	177		71	65
Germany		138		73	48
Italy	8	197	36	60	96
Greece	17	83	44	56	58

Based on the information presented on Table 7, the less capital intensive crops (ranging from 650 €/ha to almost 900 €/ha are cardoon and switchgrass for all countries while sweet sorghum has low production costs in Italy.

The cost performance of the two perennials can be attributed to their establishment with seeds and their small requirements in respective inputs during their establishment and cultivation.

The significantly lower production costs for sweet sorghum in Italy compared to the ones in Greece are due to the fact that the latter is irrigated to achieve the reported yields.

In terms of cost per tonne of produced feedstock sweet sorghum is the most effective as its fresh biomass yields are rather high compared to the other examined crops.

A detailed breakdown for the share of labour in the total production costs is presented in Table 8 below. This information is used to further estimate the number of jobs generated for each crop per country.

[10] Soldatos P, Lychnaras V, Panoutsou and Cosentino SL, Economic viability of energy crops in the EU: the farmer's point of view. *Biofuels Bioprod Bioref* **4**:637–657 (2010).

[11] Zegada-Lizarazu W, Elbersen W, Cosentino SL, Zatta A, Alexopoulou E, Monti A, Agronomic aspects of future energy crops i n Europe. *Biofuels Bioprod Bioref* **4**:674–691(2010).

Table 8. Cost Breakdown in resource inputs

	France	Germany	Italy	Greece
Sweet sorghum				
Land	10%		18%	29%
Labour	15%		12%	12%
Machinery	16%		15%	21%
R. Materials	57%		59%	16%
Energy	12%		14%	22%
Cost (€/ha)	950		650	1.200
Maize				
Land	10%	20%	18%	29%
Labour	15%	12%	12%	11%
Machinery	16%	16%	15%	21%
R. Materials	57%	55%	59%	16%
Energy	12%	16%	14%	23%
Cost (€/ha)	1.479	1.179	1.738	1.000
Cardoon				
Land			22%	28%
Labour			8%	10%
Machinery			15%	10%
R. Materials			59%	42%
Energy			14%	10%
Cost (€/ha)			650	800
Switchgrass				
Land	15%	33%	24%	33%
Labour	14%	9%	10%	7%
Machinery	14%	11%	11%	11%
R. Materials	53%	41%	51%	42%
Energy	5%	6%	5%	6%
Cost (€/ha)	1024	694	1299	1150
Miscanthus				
Land	13%	22%	17%	31%
Labour	17%	16%	17%	15%
Machinery	15%	13%	12%	11%
R. Materials	45%	37%	44%	33%
Energy	10%	12%	10%	10%
Cost (€/ha)	848	870	896	847

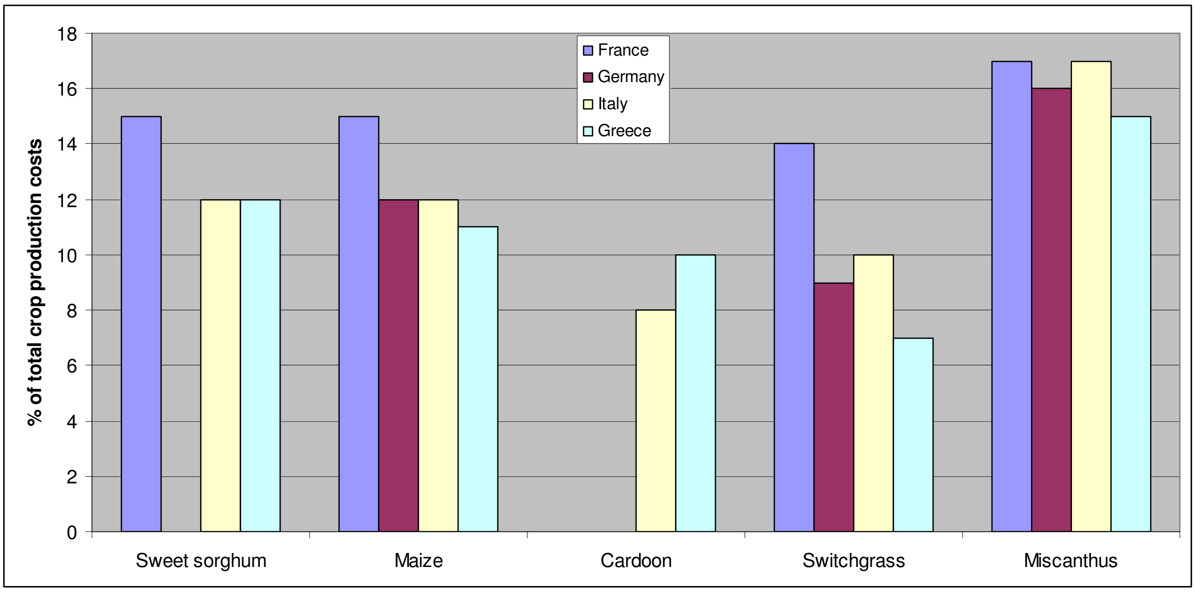

Figure 8. Labour share (%) in the total crop production costs

Both sweet sorghum and maize have labour shares between 12% and 15% as they require substantial labour input during the cultivation phases (irrigation, fertilisers, herbiciding, etc.).

As expected the two perennials, established with seed, cardoon and switchgrass have labour shares lower than 10% as they require lower labour input during the establishment phase and significantly less extensive practices during their annual management routines.

Miscanthus present the highest labour shares among the analysed crops due to the labour intensive establishment phase.

Income & Jobs

The analysis estimated the income per land area (ha) and the additional jobs (direct & indirect) generated by the cultivation of each crop in the different countries. Table 8 below presents the respective figures.

Table 8. Income & jobs generated (per 100 ha) by crop and country.

	Crop	Country	Input	Income(€/ha)	Net Additional Direct Jobs / 100 ha	Net Additional Indirect [12]Jobs/ 100 ha	Total Net Additional Jobs/ ha
1	Sweet Sorghum	Italy	Low	104	2	13	15
			High	180	3	12	15
2	Sweet Sorghum*	Greece	Low	98	4	14	18
			High	150	4	15	19
3	Maize	Germany	Low	280	2	10	12
			High	411	3	13	16
4	Maize	France	Low	245	3	11	14
			High	374	3	15	18
5	Maize	Italy	Low	293	2	11	13
			High	476	3	12	15
6	Maize*	Greece	Low	-50	3	15	18
			High	124	5	17	22
7	Cardoon	Italy	Low	50	2	12	14
			High	200	3	17	20
8	Cardoon	Greece	Low	26	4	14	18
			High	182	6	20	26
9	Miscanthus	Greece	Low	35	3	15	18
			High	164	5	21	26
10	Miscanthus	Germany	Low	162	2	12	14
			High	300	3	14	17
11	Miscanthus	France	Low	95	3	12	15
			High	272	3	14	17
12	Miscanthus	Italy	Low	25	2	13	15
			High	145	4	17	21
13	Switchgrass	France	Low	46	3	12	15
			High	150	4	14	18
14	Switchgrass	Italy	Low	42	3	13	16
			High	167	5	15	20
15	Switchgrass	Greece	Low	25	2	15	17
			High	170	5	17	22

[12] Indirect jobs refer to the jobs in the industries supporting the crop cultivation resource inputs (i.e. fertilizers, equipment, propagation material, etc.)

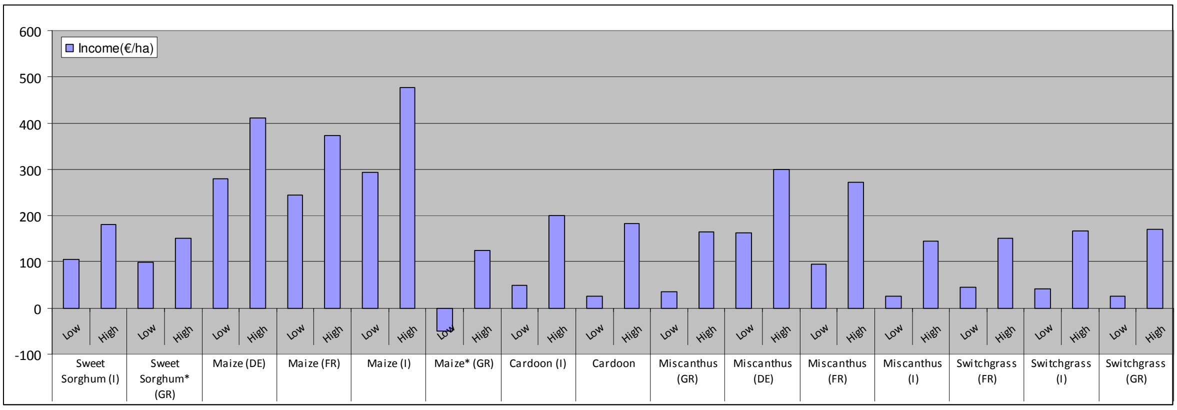

Figure 9. Income generated by the cultivation of the selected crops in each country.

From Figure 9 above that the most profitable options among the selected crops are maize in Germany, France and Italy for the high yielding case resulting at income above 360 €/ ha, while miscanthus in the German high case also have high income reaching 300 €/ ha. Values close to 200 €/ ha are exhibited by cardoon in the Italian & Greek high cases as well as switchgrass in the respective ones. Finally sweet sorghum has an income of 180 €/ ha in the Italian high case. It is well worth mentioning that values are very crop & site specific and sensitivity analysis is required if one would like to estimate more precise numbers for feasibility studies.

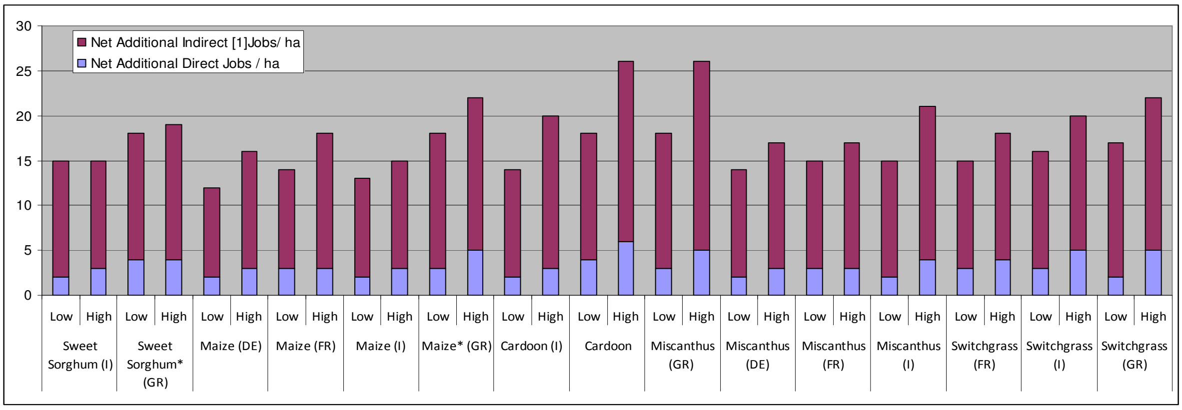

Figure 10. Jobs (direct & indirect) generated (per 100 ha) by the cultivation of the selected crops in each country.

Miscanthus & Cardoon in the Greek high case are the most labour intensive (due to irrigation and rhizome establishment for the latter) resulting to more than 25 jobs per each 100 ha of cultivated land. The rest of the crops exhibit values in the range of 15-20 jobs per each 100 ha of cultivated land, with sweet sorghum in Greece (both high & low cases) as well as switchgrass in the Greek & Italian high cases having the higher ones. As mentioned before, data are case sensitive so more detailed analysis is required at the feasibility study level.

Conclusions

This work illustrates a combined methodological approach of a quantitative matrix analysis and modelling capabilities along with the integration of cost data in the model and defining income and jobs generated for each crop.

In general terms perennial crops with lower inputs and seed propagation (cardoon and switchgrass) perform well under this type of analysis as they have mostly beneficial impacts to the ecosystem as well as due to their high yielding potential are financially attractive options for farmers.

At the other end of the spectrum, annual food crops like wheat and rapeseed have low performance due to lower yielding capacity, high inputs in herbicides & pesticides and relatively low economic & GHG abatement performance.

The case studies analysed represent the production and other agronomic characteristics of the climatic zone which each case study represents, but the both the financial data, costs and income/ jobs (land rent, labour cost, etc.) depend upon the agronomic management practices in the country of the case study.

Regarding income and job generation, it is mostly the perennials and maize that excibit the highest values with sweet sorghum following.

On the country analysis, Italy presents the best scores for most of the selected crop options analysed with Germany, France and Greece following.

At the final point It is well worth mentioning that values are very crop & site specific and sensitivity analysis is required at the feasibility study analysis for each case.

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