Applied Mathematical Sciences Vol. 8, 2014, no. 132, 6635 - 6649
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ams.2014.46438

A GIS-Based Territorial Model for Energy Balance Evaluation of Corn-to-Ethanol Process: an Italian Case Study

Roberta Martelli

Department of Agrifood Sciences and Technologies, University of Bologna
Via G. Fanin, 50, 40127 Bologna, Italy

Claudio Caprara

Department of Agricultural Sciences, University of Bologna
Via G. Fanin 48, 40127 Bologna, Italy

Abstract

A territorial analysis was carried out to provide the main elements of agricultural land use planning for a bioethanol production chain. A model was developed at a regional level in a GIS environment where the land use map of Emilia-Romagna region was integrated with alphanumerical data on the energy inputs and outputs related to corn production.

A simulation was done converting part of the areas previously cultivated with sugar beet and vacated by the sugar industry sector reorganization to the cultivation of corn for bioethanol production. Data allows to foresee the location of two ethanol plants in the Emilia-Romagna region. An energy analysis was carried out on a territorial base to highlight the energy expense due to corn production, transportation and processing into ethanol. Energy balances were calculated for each single supply area as the ratio of output/input, considering coproducts energy credit as part of the energy output. Energy balances vary in a small range of 1.15443 - 1.16576 according to supply areas and corn yields.

Keywords: Renewable energy, GIS, Corn, Ethanol, Energy balance

Notation

Adm_bound_i	Administrative area boundaries (Municipality) (ha)
A_k	Homogeneous area, intersection between Adm_bound_i and $Land\_use_j$ (ha)
c_{af}	Gas oil average consumption (0.33-0.36 l/km)
D_k	Distance from the centre of each *k* area to the processing plant (km)
E_{ao}	Energy expense for agricultural operations and Diesel oil (MJ ha^{-1})
Eic_k	Energy input for farming activities in each *k* area (MJ)
Ei_k	Total energy input in each *k* area (MJ)
Eip_k	Energy input for corn conversion into ethanol in each *k* area (MJ)
Eit_k	Energy input for corn grain transport in each *k* area (MJ)
$Eocop_k$	Coproducts energy credit for each *k* area (MJ)
$Eoeth_k$	Ethanol energy output for each *k* area (MJ)
E_p	Corn processing energy input (MJ l^{-1})
E_{rm}	Raw materials energy expense (MJ ha^{-1})
$Land\_use_j$	Land use area (ha)
LHV_{eth}	Ethanol lower heating value (26.79 MJ/kg)
LHV_f	Gas oil lower heating value (42.68 MJ/kg)
M	Loading capacity of trucks for corn grain transportation (30 t)
NT_{cop}	Net value of coproducts energy credit (4.01 MJ l^{-1})
R_{Buffer}	Circular object representing the supply basin
r_{ceth}	Conversion ratio grain/ethanol (0.37 l kg^{-1})
RE_k	Ratio of energy outputs to energy inputs for each *k* area
Y	Corn grain yield (t ha^{-1})
Y_{pa}	Provincial corn grain average yield (t ha^{-1})
Y_{ra}	Regional corn grain average yield (t ha^{-1})

Greek Symbols

γ	Specific fuel consumption for corn transporting trucks (MJ km^{-1})
ρ_{eth}	Ethanol density at 20° C (0.79 kg/l)
ρ_f	Gas oil density at 20° C (0.815-0.855 kg/l)
τ_1	Factor that considers the return journey with the unloaded truck (1.5)
τ_2	Factor that considers the non-linearity of the street route (1.5)

Subscripts

k	index referred to homogeneous areas
i	index referred to administrative areas
j	index referred to land use areas

1 Introduction

The interest in renewable energies has been favoured by a number of factors in the last years. Increasing oil consumption and prices together with the emissions reduction goals stated by the Kyoto Conference have challenged the European Union in finding energetic development programmes that promote renewable sources use. One of the EU energy policy main aims was supporting the use of biofuels in transport sector. The Directive 2009/28/EC on the promotion of the use of energy from renewable sources in the EU (RED) [3, 21] in fact, established mandatory target and introduced a 10% binding minimum target for renewable energy sources in transport by 2020. To facilitate the achievement of these goals a policy-driven demand to encourage an increased use of renewable fuels in the transport sector was promoted. The mandatory targets set by RED require a very high demand for biomass that the current use of forest resources, wastes of food processing industry will not be able to meet, so agriculture is required to provide feedstock by crop residues and dedicated energy crops. In particular, the gap to be covered by the European Union is still very large with regard to the market of biofuels. Indeed, for the production of ethanol, the most common biofuel, Europe contributes just for 4.5 billion liters, which corresponds to only 5% of the world production [19].

The Italian National Renewable Energy Action Plan (PAN) [12] defined guidelines to achieve the targets at 2020. Energy consumption in the transport sector is estimated at 33,973 ktoe in 2020 and the requirement of 10% will be achieved mainly by means of biofuels. The Italy PAN estimate the achievement of this target through the production of 600 ktoe for bioethanol, 1880 ktoe for biodiesel and 50 ktoe for biomethane and vegetable oils.

Waiting that the European Commission revising the section of Directive 2009/28/EC covering biofuels and bioliquids (scheduled for 2014), Italy has confirmed the 2020 target of 10% for biofuels which, in terms of the costs to the system, could reach about €1 billion and in terms of quantity amounts to about 2.5 MTOE/year (National Energy Strategy, [13]). The National Energy Strategy also sets out to will push as strongly as possible for the adoption of second generation biofuels while preserving however the investments already made on the production of first generation biofuels. Indeed the technology to completely replace first generation “conventional” production to the second and third generation, is not yet sufficiently developed [13]. Against this technical and political context, must be added the restrictions on authorizations for imports of biofuels produced in non-EU Countries introduced by European rules that requires a greater contribution by member states in biofuels production.

Many of the crops for energy purpose are food crops (wheat, corn, soybean, sunflower, etc.) and they may be used as biofuels source. Some dedicated energy crops, both annual and perennial, that would have a high productivity, as sweet sorghum, *Arundo donax, Miscanthus* spp. show often critical issues in relation to harvest and storage technique, low input response and mechanization [2, 4].

Corn is a culture particularly suitable for ethanol production and with high suitability for the areas of Northern Italy where, following the 2006 reform of sugar Common Market Organisation (European Council, 2006) were released large areas prior cultivated with sugar beet. The sugar industry reorganization has in fact resulted in the closure of 13 of 19 processing plant with the drastic reduction of the crop districts from 253,000 to 61,000 ha [9]. Further reductions in the area of sugar beet cultivation are expected following the abolition of the quota regime planned for 2017.

Thanks to specific EU funds destined to sustain sugar beet farms and factories that will cease beet cultivation or transformation [6], the plan for rationalization of sugar-beet production [11] provides for the conversion of 9 sugar plant for building 15 biomass plants that would provide new opportunities for the excluded areas from the sugar beet cultivation. In particular, the plan provided for the construction of four plants for the bioethanol production and two for biodiesel.

The aim of this study was to assess the suitability of the development of a corn to ethanol production chain at a local level in the Emilia-Romagna region, by assuming the conversion of areas previously cultivated with sugar beet to biomass production. Analysis on the energy efficiency was carried out to assess the sustainability of the energy conversion in the considered areas.

2 Methods

2.1 GIS model implementation

In order to define an ethanol production chain, corn was considered because it is one of the main crops commonly grown in the world as raw material for ethanol production [14].

Moreover corn is a very well established crop in the Emilia-Romagna region where it registers high yields. Thus, it would not carry any problems connected with the introduction of some of dedicated energy crops that does are not well established and can show critical issues in relation to cultivation techniques and mechanization.

The basis for the development of the model is the conversion hypothesis of 60% of the areas prior cultivated with sugar beet into corn-to-ethanol farming, in relation to sugar industry sector reorganization that resulted in a significant reduction of areas cultivated with sugar beet. Integration among all the information layers that build up the model (Fig. 1) is achieved by using a Geographic Information System; software *MapInfo 8.0* was used for this territorial analysis. Cartography was supplied by the Cartography Service of Emilia-Romagna Region using administrative boundaries map and land use map as territorial base.

Intersection of these maps defines homogeneous areas used as a base for all the elaborations. Maps intersection is achieved with SQL queries by means of calculation algorithms deriving from the set theory.

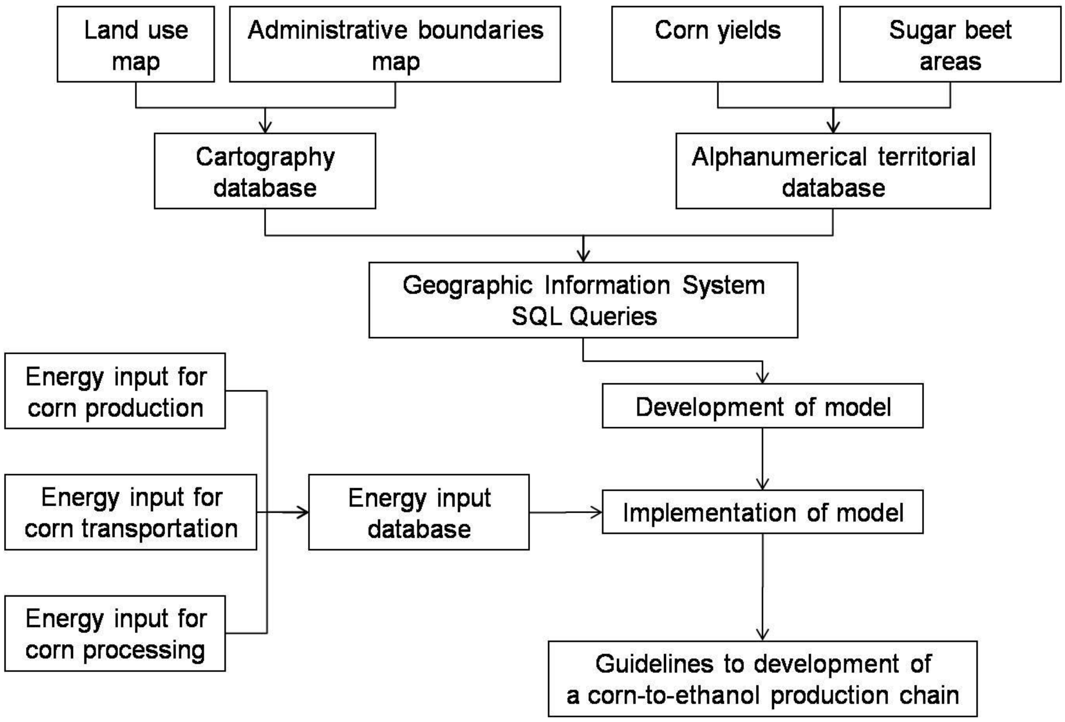

Figure 1. Flowchart of GIS model implementation.

If we indicate the set of areas defined by administrative boundaries as:

$$\mathbf{Adm\_bound} = \{Adm\_bound_i; i = 1, \ldots, \mathrm{I}\} \tag{1}$$

and the set of areas defined by land use as:

$$\mathbf{Land\_use} = \{Land\_use_j; j = 1, \ldots, \mathrm{J}\} \tag{2}$$

where j represents all possible attributes of land use (Table 1), then each homogeneous area is obtained via an intersection described as follows:

$$A_{ij} = Adm\_bound_i \cap Land\_use_j \tag{3}$$

and the set of all homogeneous areas may be represented as:

$$\mathbf{A} = \{A_{ij}; i = 1, ..., \mathrm{I}; j = 1, ..., \mathrm{J}; A_{ij} \neq \varnothing\} \equiv \{A_k; k = 1, \ldots, \mathrm{I} \cdot \mathrm{J}; A_k \neq \varnothing\} \tag{4}$$

According to this work basis, only homogeneous areas in which land use attribute is “arable land” will be considered.

Table 1. Features of land use classification.

Numerical code	Area typology
1	Urbanized areas
2	Industrial areas
3	Railway and road networks
4	Airports
5	Port areas
6	Extractive and dump areas
7	Urban green areas and sporting facilities
8	Arable lands
9	Rice fields
10	Vineyards
11	Orchards
12	Olive groves
13	Vegetable gardens, nurseries, greenhouse cultivations
14	Poplar groves
15	Chestnut woods
16	Grass areas
17	Grasslands and heathlands
18	Mixed agricultural areas
19	Broad-leaved woods
20	Coniferous woods
21	Reforestation areas
22	Bush areas
23	Wetlands
24	Salty valleys
25	Rivers
26	Lakes
27	Coastal beaches
28	Sea

Alphanumerical information refers to provincial data on corn grain yield calculated as an average of a ten year yield data (Table 2), and on crops distribution in each Municipality [5, 10].

Table 2. Corn grain average yield in the Emilia Romagna Provinces.

Province	Average Yield ($t\ ha^{-1}$)	Standard Deviation ($t\ ha^{-1}$)
Bologna	8.569	1.051
Ferrara	8.867	1.179
Ravenna	8.018	0.783
Modena	9.417	0.534
Parma	9.577	0.647
Reggio Emilia	9.431	0.058
Piacenza	10.003	0.962
Forlì-Cesena	7.214	0.487
Rimini	6.633	0.830

2.2 Energy balance

Table 3. Overall energy inputs [8, 17, 18].

Energy input	Value
Corn farming: raw materials (except for Diesel oil)	E_{rm} = 16913 MJ/ha
Farm operations + Diesel oil	E_{ao} = 9548 MJ/ha
Corn transportation	γ = 12.25 MJ/km
Conversion ratio grain/ethanol	r_{ceth} = 0.37 l_{eth} /kg_{corn}
Ethanol processing	E_p = 15.70 MJ/l_{eth}

Territorial information allows to set the potentially available agricultural land for corn farming according to the previously cited assumption (conversion of 60% of areas traditionally cultivated on sugar beet). This information together with the energy inputs database allow to calculate the energy balance based on each considered area, assuming to convert corn grain into ethanol.

Calculation of all the energy inputs (Table 3) necessary to pass from corn grain to ethanol production in a generic *k* area results from Eqn (5):

$$Ei_k = Eic_k + Eit_k + Eip_k \tag{5}$$

where:

$$Eic_k = A_k \cdot \left[\left(E_{rm} \cdot \frac{Y_{pa}}{Y_{ra}} \right) + E_{ao} \right] \tag{6}$$

Eic_k represents the energy input corresponding to agricultural activities and it depends on the area A_k and on E_{rm} and E_{ao} factors. A_k area is the smallest area on which all the elaborations are made. The first factor (E_{rm}) represents raw materials energy expense which varies with corn yield: in order to consider yield variability over the provinces it was necessary to calculate a deviation factor of provincial yield from regional yield, resulting in the ratio Y_{pa}/Y_{ra} (Table 4). The second factor

(E_{ao}) represents the energy expense for agricultural operations and diesel oil, which do not vary noticeably with yield.

Table 4 Correction factor for average provincial yield based on regional average yield.

Province	Y_{pa} [a] (t ha^{-1})	Y_{pa}/Y_{ra} [b]
Bologna	8.569	0.959
Ferrara	8.867	0.993
Ravenna	8.018	0.898
Modena	9.417	1.054
Parma	9.577	1.072
Reggio Emilia	9.431	1.056
Piacenza	10.003	1.120
Forlì-Cesena	7.214	0.808
Rimini	6.633	0.743
Regional yield (Y_{ra})	8.932	

[a] Average provincial yield (Table 2).
[b] Deviation factor of provincial average yield from regional average yield.

$$Eit_k = A_k \cdot Y \cdot \frac{Y_{pa}}{Y_{ra}} \cdot \frac{1}{M} \cdot \tau_1 \cdot \tau_2 \cdot D_k \cdot \gamma \qquad (7)$$

Eit_k is the energy input for corn grain transport from the field to the transformation plant and it depends on: grain yield in each k area ($A_k \cdot Y \cdot (Y_{pa}/Y_{ra})$); factor M that represents the loading capacity of a usual truck used for grain transport (30 t); D_k, distance from the centre of each area to the processing plant; two coefficients τ_1 e τ_2, respectively a 1.5 factor that considers the return journey with the unloaded truck and another 1.5 factor necessary to take into account the route non-linearity. Coefficient γ expresses specific consumption of fuel for the truck:

$$\gamma = LHV_f \cdot \rho_f \cdot c_{af} \qquad (8)$$

LHV_f is gas oil lower heating value (42.68 MJ/kg); ρ_f is gas oil density at 15° C (0.815-0.855 kg/l); c_{af} is an average consumption (a value of 0.33-0.36 l/km was considered).

All this data derives from the analysis of normal conditions for corn grain transportation in Emilia-Romagna region.

$$Eip_k = A_k \cdot Y \cdot \frac{Y_{pa}}{Y_{ra}} \cdot r_{ceth} \cdot E_p \qquad (9)$$

Eip_k represents the energy input for corn conversion into ethanol. It depends on

A_k area, grain yield plus deviation factor from the regional average yield ($Y \cdot (Y_{pa}/Y_{ra})$), and on $r_{ceth} \cdot E_p$ which is the transformation energy input per mass unit, a fixed value for the each plant. Different authors report quite similar data regarding the E_p value of the energy balance [8, 17, 18].
The ratio of energy outputs to energy inputs for each k area is the expression of energy balance for the corn-to-ethanol process as reported in Eqn (10):

$$RE_k = \frac{Eoeth_k + Eocop_k}{Ei_k} \tag{10}$$

where:

$$Eoeth_k = A_k \cdot Y \cdot \frac{Y_{pa}}{Y_{ra}} \cdot r_{ceth} \cdot \rho_{eth} \cdot LHV_{eth} \tag{11}$$

$$Eocop_k = A_k \cdot Y \cdot \frac{Y_{pa}}{Y_{ra}} \cdot r_{ceth} \cdot NT_{co} \tag{12}$$

$Eoeth_k$ represents the ethanol energy output as a fuel. It depends on ethanol lower heating value LHV_{eth} of 26.79 MJ/kg, A_k area, grain yield and r_{ceth}.
Energy credit for the processing coproducts is included among the outputs. The coproducts of the fermentation process are: DDGS (Distillers Dried Grains with Solubles), that is produced by blending corn distillers liquid solubles on the wet corn distillers grains before being dried [1]; corn oil; corn gluten meal and corn gluten feed. These distillers coproducts are an excellent feed resource for cattle that can be fed at 6% to 15 % of the diet dry matter, primarily as a source of supplemental protein [15].
Coproducts can then partially reduce both energy and economic costs of ethanol processing, being a good product as ruminants feed. DDGS is generally a substitute for soybean meal, thus it is possible to calculate the quantity of soybeans and soybeans protein required to replace the wet mill products.
There are different ways to calculate coproducts energy credit, but the most reliable one seems to be the substitution value of ethanol in respect of other animal feed products. The substitution value is the only one that can be measured in energy units and as a matter of fact it represents the lowest value among other values deriving from different calculation methods [20].
$Eocop_k$ can then be considered as a prudential estimate of the coproducts energy credit. It depends on A_k area, grain yield plus deviation factor from the regional average yield ($Y \cdot (Y_{pa}/Y_{ra})$), and on conversion ratio grain/ethanol r_{ceth}. Based upon replacement the estimated credit was 4.01 MJ/l [8].

2.3 Supply basin determination

The research hypothesis implied the choice of medium size processing plants (57 Ml of ethanol produced every year equivalent to 15 Mgal/yr). In fact, considering average corn yields in the Emilia-Romagna region the chosen size seems to be the best scale to exploit grain yields and at the same time it can be considered as a realistic plant size, since it has already been used for several plants in those countries that already produce large amounts of ethanol.
Supply basins and plants location are conditioned by the distribution of corn producing areas and its yields. In order to calculate the basin size in the GIS environment it was necessary to define an object corresponding to a circular area of variable radius and to use a SQL query that select the arable lands within Municipalities inside the circle:

$$\{A_k; A_k \cap R_{Buffer} \neq \varnothing\} \quad (13)$$

where R_{Buffer} represents the circular object and A_k represents arable lands in the regional territory.

3 Results and discussions

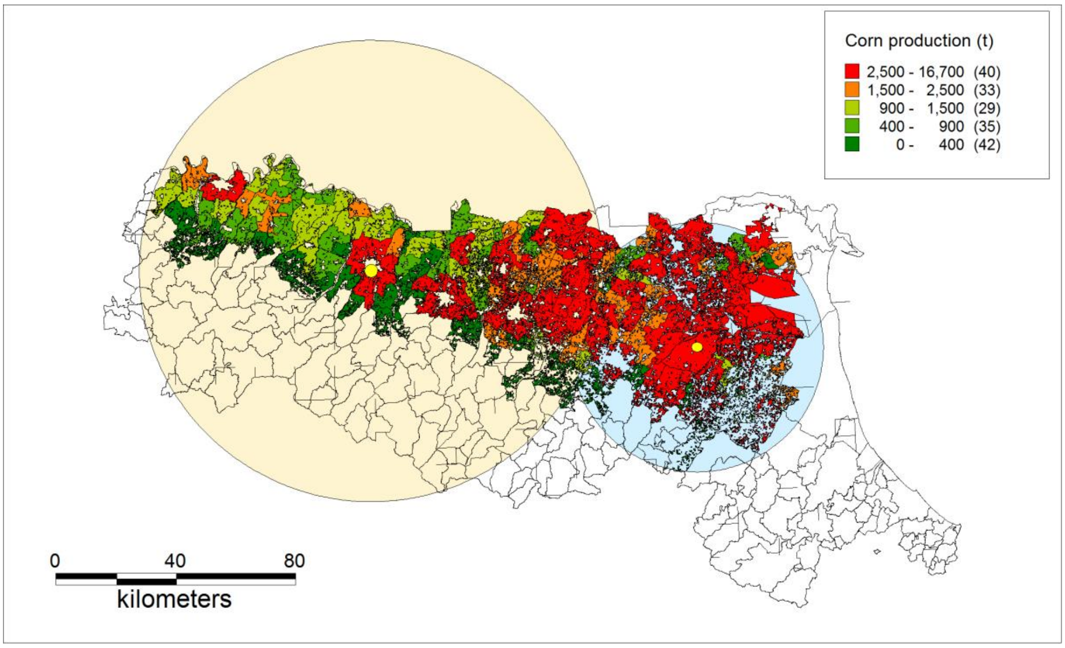

Figure 2. Corn production map: the two circles represent the supply basins for the two hypothesized plants.

On the basis of the conversion ratio r_{ceth}, 153,330 t of corn grain are necessary to feed a 57 Ml/yr ethanol plant. Supply basins and plants location are conditioned by the distribution of corn producing areas and its yields. Considering average corn yields two ethanol plants of the indicated capacity are foreseeable in the region (Fig. 2).

The best locations for the two plants were identified as those sites in which it is possible to minimise distances from each supply area. Therefore they result in being located in the centre of the circular areas that were considered as supply basins. These are represented as a small circle in the centre of circular areas (Fig. 2).

To guarantee a feeding capacity of 153,330 t/yr of corn grain to each plant, the first supply basin must have a radius of 75 km, while in the second case it is sufficient a radius of 40 km.

Energy input for farming operations has a territorial distribution directly proportional to corn yield (Eqn (6)) and it is represented in Fig. 3.

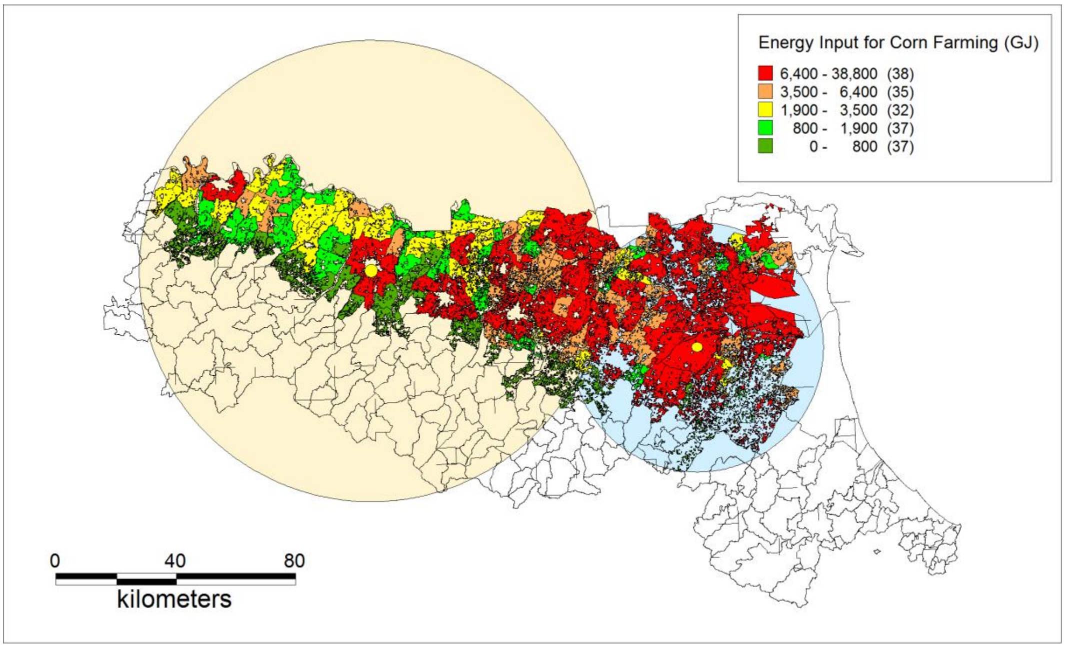

Figure 3. Map of energy input for corn cultivation.

Transport energy input (Fig. 4) depends not only on distance of the cultivation area from the plant but also on yield (Eqn (7)) and hence it is possible that areas close to the plant present energy inputs higher than areas further away. If transportation is considered for its energy contribution to the total energy expense, we can see how it represents only a modest part of the total.

Fig. 5 shows the distribution map of energy balance index, calculated as the ratio of output/input, considering coproducts as part of the energy output (Eqn (10)). Energy balance varies in a small range of 1.15443-1.16576 according to supply areas and corn yields.

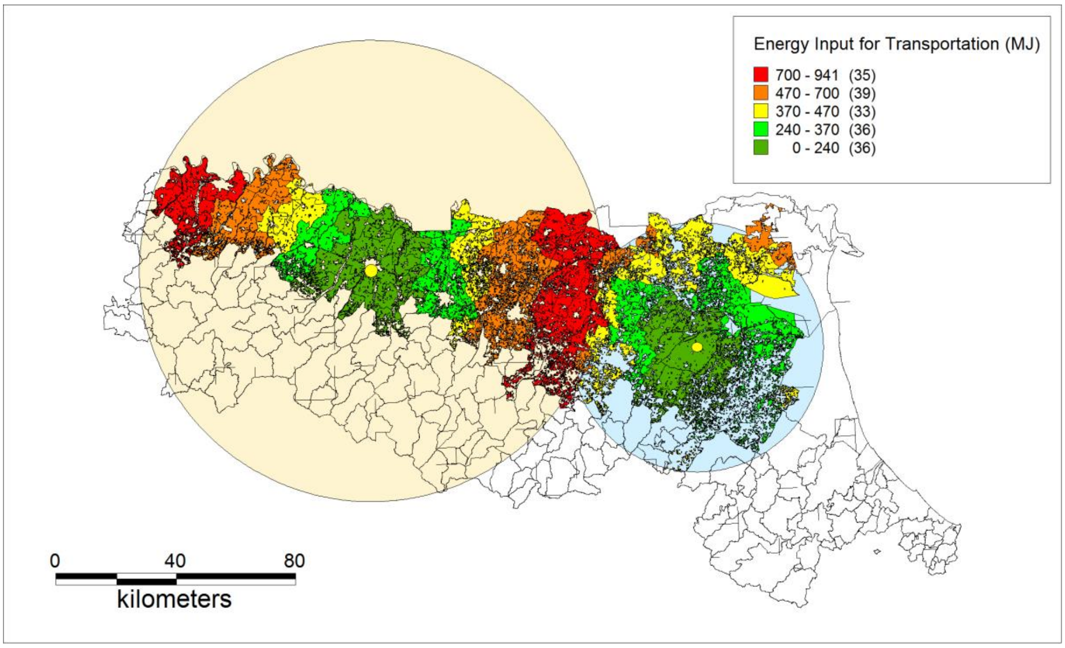

Figure 4. Energy input for transporting corn from the farming area to the plant.

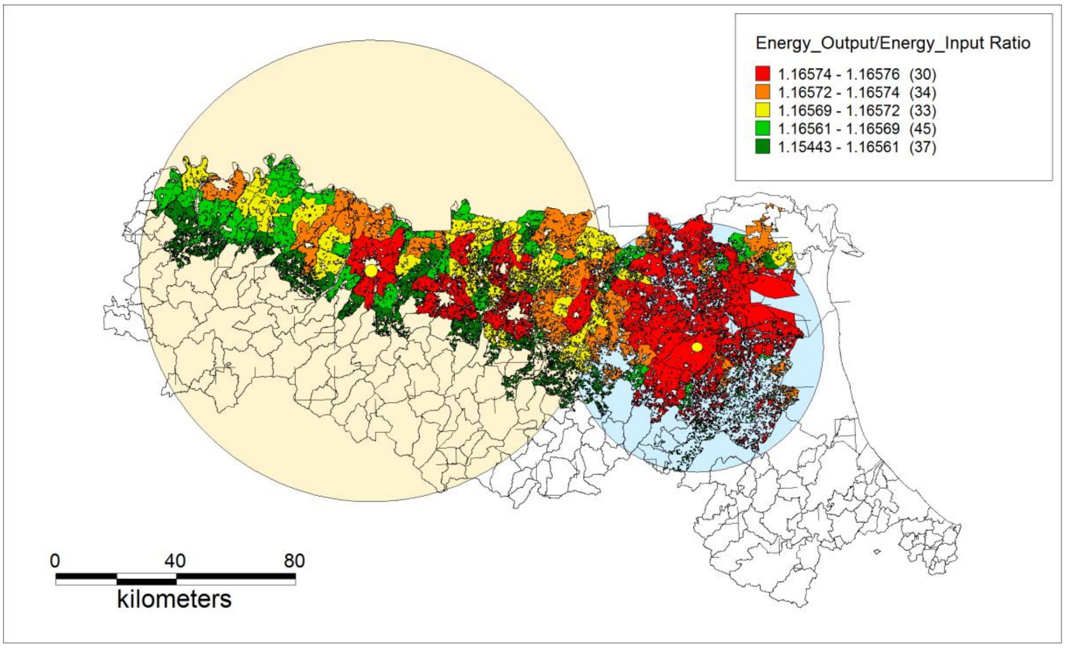

Figure 5. Map of energy balance including coproducts credits.

The inclusion of coproducts in the energy balance leads to a positive result as indicated by other studies [7, 16].

4 Conclusions

The production of bioethanol could be assured by food crops cultivation as corn as considered in this specific case study but its cultivation require high energy inputs. The energetic sustainability of corn grown in districts prior cultivated on sugar-beet is variable and is strongly influenced by the inclusion in the energy balance of energetic credit of coproducts.
Concerning costs per hectare of cultivation and delivering, corn grains transport is a fixed value per km. Thus it depends on distance and yields, whereas processing energy input is not influenced by variables that can be controlled during the farming phase, but it could be reduced using more mature technologies in order to increase processing plants efficiency.
More favourable energy balances correspond to those Municipalities with a good yield and with a larger area available for corn farming. These aspects lead to the conclusion that important factors for increasing the energy efficiency of the overall process are the size of areas converted from food to no-food crops and the introduction of high yielding corn varieties.
The region analysed in this paper is new to the ethanol industry, even though agriculture has always represented a strong economy sector. Nevertheless the crisis that gripped the sugar market pushed this sector to open up to different perspectives for the future and this study could represent a useful background for further studies aimed at analysis of energy supply chains that could offer opportunities for the areas prior cultivated with sugar beet.

References

[1] R.L. Belyea, K.D. Rausch, M.E. Tumbleson, Composition of corn and distillers dried grains with solubles from dry grind ethanol processing, *Bioresource Technology*, **94** (2004), 293 - 298.

[2] M. Bentini, R. Martelli, Prototype for the harvesting of cultivated herbaceous energy crops, an economic and technical evaluation, *Biomass and Bioenergy*, **57** (2013), 229-237.

[3] Commission of the European Communities, 2009. Directive 2009/28/EC of the European Parliament and of the council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, European Commission, Belgium, 2009/28/EC, April 2009.

[4] S.L. Cosentino, V. Copani, C. Patanè, M. Mantineo, G.M. D'Agosta, Agronomic, energetic and environmental aspects of biomass energy crops suitable for Italian environments, *Italian Journal of Agronomy*, **2** (2008), 81-95.

[5] Emilia Romagna Region, 2014. Statistiche Emilia Romagna, Agricoltura. Available at: http://statistica.regione.emilia-romagna.it/agricoltura [accessed on April 2014].

[6] European Council, 2006. Council regulation (EC) No 318/2006 of 20 February 2006 on the common organisation of the markets in the sugar sector, Official Journal of the European Union (2006).

[7] A.E. Farrel, R.J. Plevin, B.T. Turner, A.D, Jones, M. O'Hare, D.M. Kammen, Ethanol can contribute to energy and environmental goals, *Science*, **311** (2006), 506 - 508.

[8] M.S. Graboski, *Fossil Energy Use in the Manufacture of Corn Ethanol*, National Corn Growers Association, St. Louis, MO, 2002.

[9] Inea, *Annuario dell'agricoltura italiana, Volume LXII, 2008*, Edizioni Scientifiche Italiane, Napoli, IT, 2009.

[10] ISTAT, 2010. VI Censimento generale dell'agricoltura. Available at: http://www.istat.it/it/censimento-agricoltura/agricoltura-2010 [accessed on April 2014].

[11] Italian Ministry of Agriculture, Food and Forestry Ministero per le Politiche Agricole Alimentari e Forestali, 2007. Piano per la razionalizzazione e la riconversione della produzione bieticolo-saccarifera. 31 gennaio 2007.

[12] Italian Ministry for Economic Development. Italy National Renewable Energy Action Plan; 2010. <http://www.sviluppoeconomico.gov.it/images/stories/recuperi/Notizie/Piano.pdf> [accessed April, 2014].

[13] Italian Ministry for Economic Development. Italy's National Energy Strategy: for a more competitive and sustainable energy; 2013. Available at: http://www.sviluppoeconomico.gov.it/images/stories/documenti/SEN_EN_marzo2013.pdf [accessed on April, 2014].

[14] G. Koçar, N. Civaş, An overview of biofuels from energy crops: Current status and future prospects, *Renewable and Sustainable Energy Reviews*, **28** (2013), 900 – 916.

[15] S.L. Lodge, R.A. Stock, T.J. Klopfenstein, D.H. Shain, D.W. Herold, Evaluation of corn and sorghum distillers byproducts, *J. Anim. Sci.*, **75** (1997), 37- 43.

[16] R.V. Morey, D.G. Tiffany, D.L. Hatfield, Biomass for Electricity and Process Heat at Ethanol Plants, *ASAE Annual International Meeting*, 2005.

[17] T.W. Patzek, Thermodynamics of the corn-ethanol biofuel cycle. *Crit. Rev. in Plant Sci.*, **23** (2004), 519 - 567.

[18] D. Pimentel, T.W. Patzek, Ethanol production using corn, switchgrass, and wood; biodiesel production using soybean and sunflower, *Natural Resources Research*,**14** (2005), 65 - 76.

[19] Renewable Fuels Association, *Annual Ethanol Industry Outlook*, RFA, Washington, DC, 2012.

[20] H. Shapouri, J.A. Duffield, M. Wang, *The Energy Balance of Corn Ethanol: An Update*,U.S. Department of Agriculture, Office of the Chief Economist, Office of Energy Policy and New Uses. Agricultural Economic Report No. 814, 2002.

[21] K. Boubaker, A. Colantoni, L. Longo, S. Di Giacinto, G. Menghini, P. Biondi (2013). *Wind – Solar Hybrid Systems in Tunisia: an Optimization Protocol*. **7972**, 220-230.

Received: June 1, 2014