ECONOMIC, ENERGY AND ENVIRONMENTAL ISSUES OF AGROENERGY CHAINS. AN OVERVIEW OF THE EU AGRICULTURAL POLICY AND THE CONCEPT OF "MULTIFUNCTIONALITY"

JEL classification: Q13; Q16; Q18; Q27; 013; 044

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Abstract. *It is now widely acknowledged that almost all human activity is seriously dependent on energy produced from fossil fuels. Energy consumption is one of the most reliable indicators of the development and quality of life of a country and the need to satisfy the demand for energy over a certain time period is the basis of energy planning.*

The increasing demand for energy and the expected shortage in the long term solicit new strategies to fill the widening demand-supply gap. The European Commission intends to implement these strategies in a context where both environmental and social goals are considered. It is recognized that a sustainable strategy must be addressed to achieve, first of all, the following goals: guarantee the security of the energy market; minimize the environmental impact; avoid the social consequences of energy shortage; improve the quality of life in rural areas and encourage diversification of the rural economy. In recent years the RES based on agricultural production has rendered agriculture multifunctional in the context of the EU Agricultural Policy.

In this view, awareness of the multifunctional character of agriculture can act as a useful means for identifying the importance of social, environmental and economic functions, and define the best balance between them. Bioenergy production, as a function of multifunctional agriculture, can be used so as to reduce to the minimum the impact on the environment; it can also, in rural or in developing areas, enhance employment and contribute to improving this balance.

Keywords: *bionergy, RES, land competition, multifunctional agriculture, rural development, sustainability*

1. Introduction

Taking into consideration the new challenges of the CAP, in particular, since the Fischler reform, at Community level there has been a renewed interest in all those transformation processes (combustion, pyrolysis, etc..) for obtaining energy, directly or indirectly, through the use of agricultural products or derived from agricultural processing as raw materials. The use of products and by-products of agricultural processing (rapeseed and sunflower, material from forests and pruning, straw and manure) offer many opportunities to reduce fuel costs of farms and

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increase their energy self-sufficiency. Renewable energy sources, therefore, become a resource to be used as raw material in a process of industrial transformation to produce renewable energy. This reduces the overproduction problem and influences the recovery and marginal productivity of lands.

2. Biomass as a renewable energy source for multifunctional farms

Renewable energy sources or Res may be defined as any type of resource that can be regenerated at a rate that is at least equal to the speed with which humanity can consume that resource (Kaminski J., Leduc G., 2010). According to the International Energy Agency (IEA), this category includes: wind power, solar energy, geothermal energy, biomass energy, hydropower, and the energy of the waves and tides. The considerations that can be made in support of their use, and that are often mentioned in EU energy policies, are related to the fact that renewable energies permit reduction in emissions of carbon dioxide (CO_2) as required by various international treaties (i.e. the Kyoto Protocol). In addition, new conversion technologies are being developed that promise renewable energy at a competitive price in the near future. Many of these energy resources will come from local resources and will ensure greater security of supply (Cassman K.G., Liska A.J., 2007). Renewable energy can also provide a source of extra income for the farmer, but should not be considered as the main production of a farm. Renewable energy has a positive social impact, thanks to its ability to create new jobs and re-evaluate, from an economic point of view, entire agricultural regions. In this context, it also becomes a real tool of multifunctionality of farms (Van der Ploeg J.D., Roep D., 2003). In particular, the excess power generated can be sold to the authority for national energy supply, to obtain an additional income. In this way, biomass allows significant savings in energy costs in agriculture (the so-called "*no food*", agriculture a term which indicates that part of agriculture is not intended for food production and processing) (Lanfranchi M., 2003).

3. Biomass production within the EU and the Common Agricultural Policy

Biomass is often considered as the sum of all waste products and residues from harvesting or processing agricultural and forestry crops (prunings, straw, forest cuts), the residues of food production and the timber industry, energy crops (herbaceous and woody), landfill gas and residues from waste treatment, plant and animal waste (manure) and the organic part of municipal waste (Tudisca S., Di Trapani A. M., Sgroi F., Testa R., Squatrito R., 2013).

The chemical composition of plant biomass varies among species. Yet, in general terms, plants are made of approximately 25% lignin and 75% carbohydrates or sugars. The carbohydrate fraction consists of many sugar molecules linked together in long chains or polymers. Two categories are distinguished: cellulose and hemi-cellulose. The lignin fraction consists of non-sugar type molecules that act as a glue, holding together the cellulose fibers. The biomass used to produce energy, can, as explained, be generated from residual sources or from dedicated crops (so-called "energy crops"). For this reason, biomass is considered the renewable energy with the highest potential to ensure a sustainable energy supply in the future. Biomass, in fact, gives the highest performance at the lowest cost (excluding hydropower), moreover, most of the technologies and infrastructures developed for fossil fuels can be converted for its use (Lanfranchi M.,

2002). Furthermore, the products that can be obtained from biomass (mainly solid, liquid and gaseous fuels) have a wide range of uses. For this reason, for several years the European Union is committed to orient its policies towards sustainability through, for example, the development of technology and a "sustainable supply chain" (Schimmenti E., Borsellino V., Galati A., 2012). The main objective of policy "*towards sustainability*" of the CAP 2014 - 2020 is, in fact, to make bioenergy competitive and allow its development on the basis of its high potential and opportunities. Today, biomass energy (Tab. 1) produces about 19.7% of renewable energy at the Community level.

Tab. 1 - Share of renewable energy in gross electricity consumption in EU countries

Renewable Energy	%	TWh
Solar power	6,9	46,3
Geothermal power	0,9	5,9
Ocean energies	0,1	0,5
Hydraulic power	46	311
Wind power	26,4	179,2
Biomass	19,7	133
Total	100	675,9

Source: EurObserv'ER, 2012

The following table (Tab. 2) shows that Germany is the largest producer of biomass in the EU, followed by France and Sweden. Italy is the ninth.

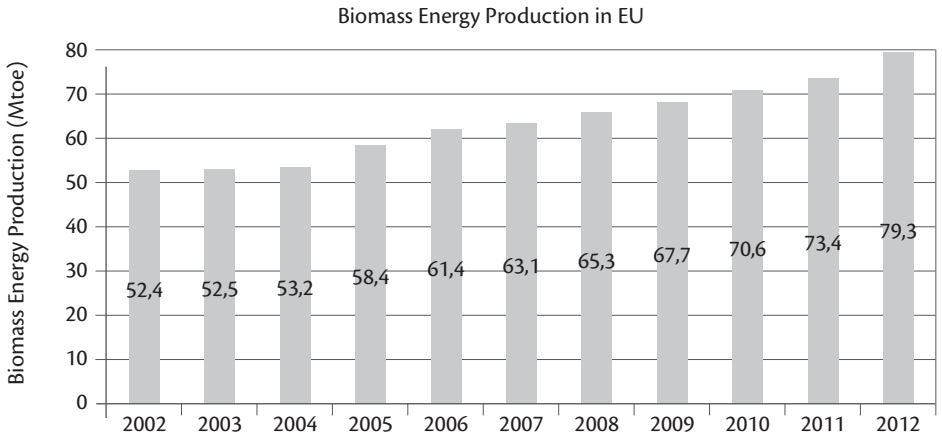
Tab. 2 - Primary energy production from solid biomass in the European Union in 2010 (in Mtoe)

	Country	Mtoe		Country	Mtoe
1	Germany	12,23	15	UK	1,442
2	France	10,481	16	Netherlands	1,033
3	Sweden	9,202	17	Lithuania	1,002
4	Finland	7,68	18	Estonia	0,924
5	Poland	5,865	19	Belgium	0,858
6	Spain	4,751	20	Greece	0,812
7	Austria	4,529	21	Bulgaria	0,788
8	Romania	3,583	22	Slovakia	0,74
9	Italy	3,019	23	Slovenia	0,572
10	Portugal	2,582	24	Irland	0,197
11	Czech Republic	2,094	25	Luxembourg	0,04
12	Latvia	1,739	26	Cyprus	0,01
13	Denmark	1,657	27	Malta	0
14	Hungary	1,489		**Total**	**79,319**

Source: Eurostat 2012

In the last decade, the use and exploitation of energy from biomass has increased exponentially in the EU, (Fig. 1). Biomass can potentially make a significant contribution to meeting the demand for heat and electricity of the population in 2020.

Fig. 1 - Solid biomass primary energy production in the EU since 2000 (in Mtoe)



Source: Eurostat 2012

However, according to the latest Eurostat surveys, Europe imports from third countries most of its raw materials for the production of energy, electricity and fuels from renewable sources.

In Europe, biomass derives principally from solid compounds, biofuels and biogas, as shown in Table 3.

Tab. 3 - Energy production from biomass in the EU (in Mtep)

Solid Biomass	72,8
Municipal Solid Waste (50% Biomass)	7,7
Biogas	8,3
Biofuel	12,1

Source: EurObserv'ER, 2012

To compensate for the shortcomings of biomass production, and to support the use of renewable energy, Europe is putting in place a series of measures through support schemes, standards and administrative rules (i.e. the allocation of revenue from ETS and the "NER 300" to promote innovative technologies).

In this context, the European Commission has suggested a sort of "farming guide" to try to produce biomass more efficiently (for example, the Communication of EC "*Renewable Energy: a major player in the European energy market*", June 2012, and also the Report of the Committee on Industry, Research and Energy "*Current challenges and opportunities for renewable energy in the European internal energy market*", April 2013). The efforts that the EU is undertaking will be necessary, given the prominent role that financial support schemes play in the development

of renewable energy. EU policies are therefore essential to reform the support schemes and to ensure that they are planned in a cost-efficient and market-oriented manner (Vieri S., 2012). To ensure convergence and Europeanization of energy, further steps are needed, in addition to the development of common approaches to support renewable energy through increased cross-border cooperation. The current legal framework provides common approaches based on specific renewable energy projects, technologies, and joint support schemes such as the Swedish-Norwegian regime, achievable within national markets. In this way, consumers are able to benefit from the renewable energy capacity produced in a neighboring country. The Commission therefore intends to promote the increase of renewable energy production (especially biomass), the control of production costs, market integration and policies to foster Europeanization. This approach will help to maintain stability between the Community and national policies and will ensure that any market intervention will be able to correct market failures without increasing the current distortions.

4. The economic potential of bioenergy and its role in sustainable development

Bioenergy is becoming an important opportunity in climate change mitigation policies. The increased utilization of bioenergy for production of heat and power has achieved increased political support in European countries. The EU Directive 2009/28, for example, aims at increasing the share of renewable energiy in the EU, in order to achieve the 2020 renewable energy goals.

Bioenergy, as demonstrated, is generally considered as contributing to many priorities, including sustainability, reduction of greenhouse gas emissions, regional development, social structure and agriculture, security of supply (Reijnders, 2006).

The current debate on the sustainability of energy crops is focused on some controversial points: competition with food and fodder crops for fertile lands (Cassman and Liska, 2007); with other human activities for water resources (Service, 2009) and their effects on the direct and indirect land use change (Fargione *et al.*, 2008).

Biomass appears to be an attractive raw material for three main reasons. First, it is a renewable resource that could be sustainably developed in the future. Second, it appears to have characteristics decidedly positive for the environment with no net releases of carbon dioxide and very low sulphur content. Third, it appears to have significant economic potential especially if fossil fuel prices increase in the future. Apart from that, biomass has the unique advantage amongst all RES, to be able to provide solid, liquid and gaseous fuels that can be stored, transported and utilized far away from the point of origin, and due to the negligible amounts of sulphur and nitrogen contained in biomass the energy that is being utilized does not contribute to environmental pollution.

It is well known that the modern use of biomass is distinguished from the traditional use of biomass energy by its conversion into high-quality energy carriers, such as electricity and biomass liquid fuels for transportation.

In the longer term, the pressure on available biomass resources will increase. Ambitions and expectations for biomass use for energy are high in many countries, for the EU and also on a global basis, given a variety of policy objectives and long term energy scenarios. A reliable supply and demand for bioenergy is vital to develop stable market activities. Given the expectations of a high bioenergy demand on a global scale, the pressure on available biomass resources will increase. Without the development of biomass resources (e.g. through energy crops and better

use of agro-forestry residues) and a well-functioning biomass market to assure a reliable and lasting supply, those ambitions may not be met. The development of truly international markets for bioenergy may become an essential driver for developing bioenergy potentials, which are currently underutilised in many regions of the world. This is true both for residues and for dedicated biomass production (through energy crops or multifunctional systems).

At the same time, many developing countries have a large technical potential for agricultural and forest residues and dedicated biomass production. Given the lower costs for land and labour in many developing countries, biomass production costs are much lower, and thus offer an opportunity to export bioenergy. The possibilities of exporting biomass-derived commodities to the world's energy markets can provide a stable and reliable demand for rural communities in many (developing) countries, thus creating an important incentive and market access that is much needed in many areas of the world. For many rural communities in developing countries such a situation would offer good opportunities for socio-economic development.

For these reasons, biomass has the potential to become one of the major global primary energy sources during the next century, and modernized bioenergy systems may well be important contributors to future sustainable energy systems and to sustainable development in developed countries as well as in developing countries (Lund and Munster, 2005).

5. The possible contribution of biomass to the future global energy supply

As already mentioned, many studies have been undertaken to assess the possible contribution of biomass to the future global energy supply. The conclusions from these studies differ significantly. Indeed, most studies focus either on the supply or on the demand side, showing that the biomass energy potential depends on both competition between biomass resource uses and competition between alternative energy technologies and primary energy sources. Nevertheless, the main conclusion of these studies is that crucial factors determining biomass energy potential (availability) are: the future demand for food, determined by population growth; the type of food production systems that can be adopted world-wide; the productivity of forest and energy crops; the (increased) use of bio-materials; the availability of degraded land, and, finally, the competition for land use.

There is, in fact, potential competition for land and water between bioenergy and food crops. Another question is whether biomass for energy use can be produced in a sustainable manner, given the current conventional agricultural production practices. Other than the land and water competition. On the other hand, there are also, sustainable alternatives, for example organic agriculture, to avoid the negative environmental effects of conventional agriculture.

It is necessary to note that all of these issues must be taken into account in the production and use of biomass for energy purposes.

6. Implications for the land system

Land use changes are a result of the interaction of a variety of drivers. Historically, the demand for more agricultural production has been partly compensated by technological advances, and improvement in technology will determine whether yields will continue to improve in the future.

It is also important to note, in this respect, the potential competition for land between

energy and food crops, based on assessments of land availability and on the interaction of increased demand for land with food production and the corresponding effects on land rents and food prices.

The growth of crops for bioenergy has been highlighted as a potential competitor for land with food crops. It is significant, though, that the area occupied by bioenergy and its by-products in 2004 was only 14 Mha compared with 1.500 Mha of crops (i.e. about 1% of the total cropped area) and 4.500 Mha of pastures worldwide (IEA, 2006). While the reasons for growing crops for bioenergy are complex, the use of land for them is likely to increase in the future (FAO, 2009).

Some models also point out the importance of regional differences in land availability. This information should be complemented with estimates of losses in arable land due to soil degradation and water scarcity due, also, to climate change that will on aggregate negatively affect agriculture and the suitability of land for farming in non-temperate climate zones.

Another important issue for competition for land is the potential clearing of new land for biomass crops. Further issues of concern are potential competition for the biomass itself between its use for energy generation and other uses, such as biomaterials or food.

Using biomass for energy is likely to have both positive and negative competitive effects on food production and therefore on land, with national and regional policies beginning to reflect differing components of these inter-linkages. With global oil stocks becoming increasingly threatened, fossil fuel prices will inevitably continue to rise and alternative sources of energy will be needed, not least to maintain agricultural yields. Bioenergy is likely to fill a significant part of this emerging energy gap for agriculture, which in turn will require more integrated energy, agriculture and land-use policies to avoid negative impacts from competition for land.

7. Awareness of the potential of bioenergy as an economic driver for rural development

It has been demonstrated how sustainable biomass production can contribute to the sustainable management of natural resources and, ultimately, to sustainable development. Biomass energy is interesting from an energy security perspective. Resources are often locally available and conversion into secondary energy carriers is feasible without high capital investment (Van den Broek, 2000). Moreover, biomass energy can have a positive effect on degraded land by adding organic matter to the soil. Furthermore, it can play an important role in reducing greenhouse gas emissions, since when produced and utilized in a sustainable way, the use of biomass for energy offsets fossil fuel greenhouse gas emissions. Since energy plantations may also create new employment opportunities in rural areas in developing countries, it also contributes to the social aspect of sustainability (Junginger *et al.*, 2001). Importing countries, on the other hand, may be able to meet their GHG emission reduction targets cost-effectively and diversify their fuel-mix. This creates important future opportunities for developing countries and regions, given the expected increased role of bioenergy within the world's energy supply. Such developments could give access to an open world energy market. Consequently, this poses the fundamental question of how these potential major producers and exporters of bioenergy can benefit from the growing global demand for bioenergy in a sustainable way, i.e., that bioenergy exports can contribute to rural development, benefit local communities and be an integral part of overall development schemes, including the existing agricultural and forestry sectors. These questions represent the

basis of the relationship between international bioenergy trade and socio-economic development and how sustainable bioenergy production could be achieved.

In particular, the social implications arising from local bioenergy investment can be distinguished in two classes: those relating to an increase in "living standard" and those that contribute to increased social cohesion and stability. In economic terms the "living standard" refers to household consumption levels, or levels of monetary income. However, other factors contribute to a person's living standard but which have no immediate economic value. These include such factors as employment opportunities, the surrounding environment and healthcare which should equally be taken into consideration. Moreover, the introduction of a net employment and income-generating source, such as bioenergy production, could help to remove adverse social and cohesion trends (e.g., high levels of unemployment, rural depopulation, etc.).

From this point of view, and in order to evaluate socio-economic impacts in the development of rural regions, it must be noted that, while many trade flows take place between neighbouring regions or countries, a large part of trade flows is spreading over increasingly long distances. This is happening in spite of the greater volume and lower calorific value of most biomass raw material. These trade flows may offer several benefits for both exporting and importing countries. For example, exporting countries may gain an interesting source of additional income and an increase in employment.

Rural areas in some countries, in fact, are suffering from significant levels of outward migration, which militates against population stability. Consequently, given the propensity for bioenergy to be located in rural areas, the deployment of bioenergy plants may have positive effects upon rural labour markets firstly, by introducing direct employment and secondly, by supporting related industries and employment in these. Large-scale production of modern biofuels, partly for the export market, could provide a major opportunity for many rural regions to generate major economic activity, income and employment (Domac *et al.*, 2005).

In economic terms, bioenergy can contribute to many important elements of national or regional development, that can carry direct and indirect economic effects on GDP and trade balance and in energy supply. A frequently mentioned obstacle to the expansion and acceptance of bioenergy into world energy markets is that the markets do not acknowledge the real costs and risks connected with the usage of fossil and nuclear fuels (Van den Broek, 2000).

Studies of socio-economic impact are commonly used to evaluate the local, regional and/or national implications of implementing particular development decisions (Hoogwijk, 2004). The extremely complex nature of bioenergy, the many different technologies involved and a number of different, associated aspects (socioeconomics, greenhouse gas mitigation potential, environment, etc.) make this whole topic a complex subject.

A major complication lies in the fact that these latter elements are not always tractable to quantitative analysis and, therefore, have been excluded from the majority of impact assessments in the past, even though at the local level they may be very significant.

It is interesting, however, to underline that the varied nature of biomass and the many possible routes for converting the biomass resource to useful energy make this topic a complex subject. When we talk about sources of biomass we need to consider forestry, agriculture, industrial residues, short rotation coppice plantations, communal waste, urban biomass, etc. This involves a combination of different economic sectors and human activities and consequently is often not well understood.

The growing dependence of the European Union on imported oil has influenced several legislative initiatives (Directives) intended to facilitate the development of biofuel markets in

Europe also to overcome increasing external dependence. The renewable energy industry is one of Europe's fastest growing sectors as member states encourage the deployment of renewable as an alternative, indigenous energy source with low environmental impact. In terms of employment, in Europe, policy-makers recognise that there are economic benefits from renewable energy (such as bioenergy), especially in terms of employment and the development of a strong export industry.

8. Conclusions

The study presented analyses the range of the global potential of biomass for energy in the long term. It is stressed that this study is exploratory, its aim was to investigate the potential contribute of bioenergy (in this case: biomass) in future scenarios of energy supply and the role of the energy policies of the EU to achieve this purpose.

It has been shown that, in most countries, socio-economic benefits of bioenergy use have been analyzed and identified as very important driving forces in increasing the share of bioenergy in the total energy supply.

Creation of regional employment and economic gains are probably the two most important issues addressed when considering biomass use for energy production. In this view, bioenergy has provided millions of households with incomes, livelihood activities and employment. The essence of sustainability of bioenergy projects from a social aspect is how they are perceived by society, and how different societies benefit from this activity in different ways. Other issues such as mitigating carbon emissions, ensuring wider environmental protection and providing security of energy supply are an added bonus for local communities where the primary driving force is much more likely to be related to employment or job creation. Overall, these benefits will result in increased social cohesion and create greater social stability.

In this view, a good understanding of and strong backing for bioenergy in EU policies are essential to encourage policies supporting the introduction and wider use of bioenergy and would also help to bring down costs further as a result of increased adoption rates and economies of scale. Similarly, a lack of awareness may result in resistance to bioenergy projects, even if they are economically viable and technologically robust.

REFERENCES

Campiotti C., Bibbiani C., Dondi F., Viola C., (2010), Efficienza energetica e rinnovabili per l'agricoltura protetta in *Ambiente, Risorse e Salute* n. 126, *bioScience* - University of California Press

Cassman K.G., Liska A.J., (2007), Food and fuel for all: realistic or foolish?. *Biofuels, Bioproducts & Biorefining* 1:18-23.

Domac J., Richards K., Risovic S., (2005), Socio-economic drivers in implementing bioenergy projects., *Biomass and Bioenergy*, Vol. 28, No. 2, pp. 97-106.

FAO (2009), *The state of food and agriculture 2009*. Rome, Italy - FAO.

Fargione J., Hill J., Tilman D., Polasky S., Hawthorne P., (2008), Land clearing and the biofuel carbon debt. *Science* 319:1235-1238.

Hoogwijk M., (2004), *On the global and regional potential of renewable energy sources*. PhD thesis, Utrecht University, Utrecht.

IEA (2006), *World energy outlook 2006*. Paris, France: International Energy Agency.

Junginger M., Faaij A., Koopmans A., Van den Broek R., Hulscher W., (2001), Setting up fuel supply strategies for large scale bio-energy projects – a methodology for developing countries. *Biomass and Bioenergy,* Vol. 21. No. 4, pp. 259-275.

Kaminski J., Leduc G., (2010), Energy efficiency improvement options for the EU food industry. *Polityka Energetyczna*, PL ISSN 1429-6675.

Lanfranchi M. (2002), *Sulla multifunzionalità dell'agricoltura*. *Aspetti e problemi*. Edas. Messina.

Lanfranchi M. (2003), Il *contributo dell'agricoltura alla sostenibilità attraverso la produzione e l'utilizzo di energia rinnovabile.* Annali Facoltà di Economia, Università di Messina.

Lanfranchi M. (2012), Economic analysis on the enhancement of citrus waste for energy production. *Journal of Essential Oil Research*, vol. 5, pp. 1-9 ISSN: 1041-2905.

Lund H., Munster E. (2005), Integrated energy systems and local energy markets. *Energy Policy*, 30(13):2402-2412.

Reijnders L. (2006), Conditions for the sustainability of biomass-based fuel use. *Energy Policy*, 34:863-76.

Schimmenti E., Borsellino V., Galati A., (2012), Recenti sviluppi del mercato comunitario e italiano del biodiesel. Primi risultati di un'indagine esplorativa in Italia. *Economia & Diritto Agroalimentare* XVII: 193-209.

Service R.F., (2009), Another biofuels drawback. *Science* 326:516-517.

Tudisca S., Di Trapani A. M., Sgroi F., Testa R., Squatrito R., (2013), Economic analysis of PV system on buldings in a Sicilian farm, *Renewable and sustainable energy reviews*; 28: 691-701.

Van den Broek R. (2000), *Sustainability of biomass electricity systems—an assessment of costs, macro-economic and environmental impacts in Nicaragua, Ireland and the Netherlands*. Utrecht University, 2000. p. 215.

Van der Ploeg J.D., Roep D., (2003), Multifunctionality and rural development: the actual situation in Europe, in Van Huylenbroeck G. - Durand G. (eds.), *Multifunctional Agriculture. A new paradigm for European agriculture and Rural Development*, Ashgate, Burlington, VT (USA) e Aldershot (UK).

Vieri S. (2012), *Agricoltura settore multifunzionale allo sviluppo*. Edagricole. Bologna.