A SYSTEMIC STUDY OF BIOFUELS IN COMPLEX AGRICULTURE MARKETS FOR THE 22ND EU BC&E – HAMBURG 2014

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ABSTRACT: During the last decade a great growth in biofuel industry all over the world has occurred. The last few years this tendency has severely changed due to new rules and pressure over the public questioning the sustainability of biofuels and their capability to achieve environmental and social solutions. In general opinions and articles were based on incomplete studies lacking a systemic and holistic view of biofuels within agriculture markets all over the world. The industry is now days in severe danger working at a low rate or closing. In this paper a systemic approach is followed looking for real impact of this industry within very complex markets were co-products are a key factor. Results are based on traceable and public figures comparing them with forecast and projections made by equilibrium models all over the word. Results are based on a complete transformation chain analysis of Argentina case as the first biodiesel exporter country until 2012 and one of the main actors in agricultural commodity markets. Prices, energy and carbon emittions balances are considered over real case studies covering different biofuels and feedstock's. The results confirm that forecast consequences are very far from real markets and land use behavior. Carbon emitions of first and second generation biofuels need to be revised and closely look at in order to compare them in a fair way.

Keywords: biofuel, biodiesel, modelling, agriculture, energy balance, policies

1 Introduction

From an analysis of the principal biofuels markets in the world with an increasing role on the last years, we find out that they are all inserted in complex agroindustrial transforming chains with several products being produced and commercialized.

Rapid growth of biofuel production in the United States Brazil and Argentina over the past decade has increased interest in replicating this development in other nations of the Pan American region. However, the continuing production of food-based feedstock has been in debate changing public perception regarding sustainability although there are no field proofs of links to deforestation, food insecurity and increased greenhouse gas emissions. This analysis lack of a holistic and systemic view of biofuels inserted in a very complex agroindustrial transforming chain.

Public perception is changed very rapidly in modern societies with plenty of media roads to reach people quikly. Different actors as oil and food companies, NGO, environmentalist publish certain reports of big impact in the general public. When the perception is changed political actors try to respond promoting changes in legislation, laws and commerce regulations.

This has been particularly strong on multipurpose crops as corn, sugarcane, soy, and others principally due that they are treated as pure energy crops not considering the rest of their end products.

Most arguments are based on results without a deep study on the methodoly that was employed in order to establish if those figures or impacts are realy comparable.

The policy system ask scientist to give support for this changes in public perception based on scientific evidence. Universities and scientific institutes need time, testing and analysis of data in order to deliver this type of information. This causes great discreapancies in speeds and although changes in legislation and regulation goes preaty fast the scientific support behind them is very weack. This is represented by the turtle and the rabbit (fig 1) and the consequences for the near future are wrong desitions and possible controversies in international courts.

On the last five years plenty of different models were used in a single or combined way in order to predict possible effects of biofuels policy and production, Based on several results obtained from them precauory measures were launched with very poor field test. The consequence on certain biofuels is that they are punished restricted or not promoted no by their real effects but based on possible changes that may or maynot occur in the future.

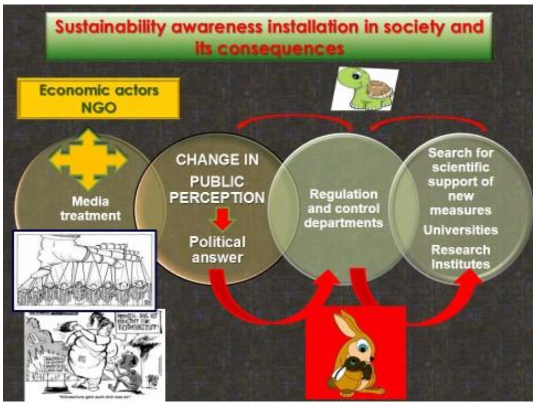

Figure 1 public perception on biofuels dynamics

In the literature review we find out that most of the studies are focused on biofuels production and final use lacking a systemic view of the whole complex were they are inserted. Biofuel chains use agronomical knowledge and experience, transportation and logistics development for inputs and outputs, industry knowhow and final delivery from well and mature chains for example: sugarcane/sugar, corn/cornmeal, soybean/soymeal/oil, forest/wood industry.

Analyzing this complex and mature systems we find out multiple interactions (fig 2) that produce uncountable effects on several industries with direct or indirect relationship with agriculture

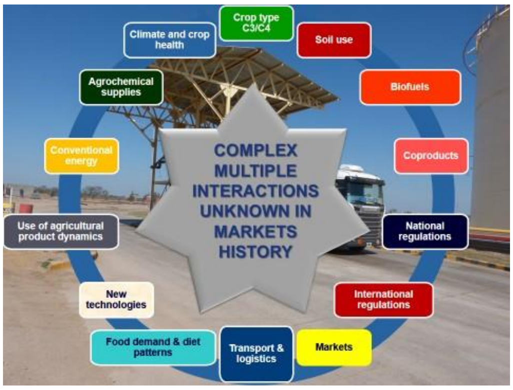

Figure 2 Interactions in transforming chains

During the last years the growth of biofuel production and commercialization and the continuous changes in domestic and foreign policies gives a good opportunity to demonstrate that conclusions and forecast of the studies made ten years ago, turn out to be very far away from what really occur since many interaction were not taken into account.

There are very few examples of studies comparing models predictions to real cases evolution along the last years were biofuels entered the international markets and policy driven policies changed several times.

This is especially important when land use is considered, farmers as principal actors in defining land use change are stimulated by end prices paid by their products without considering the final end use of them. Low prices of commodity products has always been a problem for this sector producing land abandon, low technology use etc.

When biofuels were introduced as a new end coproduct of certain crops the effect on prices caused an increase in land use and technology with a final increase of productivity since all the different chains received a new signal to invest and improve (breeders, genetics, fertilizers, agrochemical, logistics, farm machinery etc.)

Bioenergy system decisions occur at all points along the supply chain (Fig 3) and at different scales, information about sustainability indicatos can be used to inform those decisions. (1) Dale VH et al.

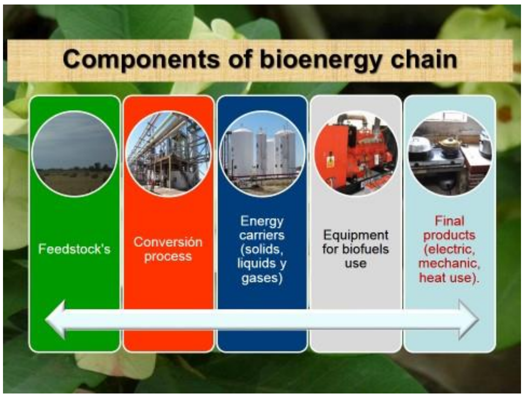

Figure 3 Components in bioenergy chain

The principal challenge in systemic approaches is finding the individual effect of the biofuels on the transforming chain and the behavior of different actors at local,region or state level. A way to approach this is making local or regional studies and looking at changes that were produced after the appearance of biofuels in the market.

There are some variables related to the specific production and use of biofuels that can be dimentioned in a rather precise way (construction and operation of transforming plants, transportations and final use). The complex effect on commodity increase demand and stability are very difficult to study but different scenarios can be proposed to find out the overall behavior of the system.

This has to be confronted with real case studies were increase and decrease in biofuel production must be analyzed with a series of parameters linked to resources use and markets prices.

The different consequences of biofuels introduction in the last 10 years can be of great help especially regarding specific country studies.

There are certain aspects regarding biofuels that should be considered:

- Relative low price of biofuel as a final product
- Foreign currency balance of the country
- Profit of the combination of products
- Added employment and value at local level
- Risk of local and foreign policy changes
- Changes in final product public perception
- Competitive use of feedstock's in present and future markets
- Working force and technology availability
- Transport & logistics

Biomass production has many possible final uses as food, feed, construction or fuel. Between them, the fuel final use usually has the lower end price. That is why looking at new costly technologies related to second-generation biofuels only high value byproducts will make them economically feasible.

2. Resources and Soil use

Biomass production needs certain resources to be produced special attention should be paid to:

- Soil use
- Water use
- Soil nutrient cycle
- Fertilizers
- Fossil energy use
- Logistic requirements

Looking at this resources it is simple to trace direct impacts when dealing with a specific energy crop but there is a great challenge to allocate them when we are using a multipurpose crop, although there are possible ways of doing this there is a need to standardize the methods, criteria and bounderies.

There are many sort of projections for first and second-generation biofuels crops in order to comply mandatory or maximum targets enforced by different countries or regions. Many of this studies don't consider that the election of a crop y mainly based on the best economic alternative for that agro ecoregion. Added to this factor there are crop rotation needs and cultural factors that also have significative influence in the crop selection.

Farmers are conservative and they look for stable and well-known markets for their products. In the case of multipurpose crops they are not significantly affected by changes in the final use of the seed, this has been proven recently with great differences in biodiesel production in Argentina not affecting the area of soybean nor the final price of grains (Fig 4) being paid to the farmers.

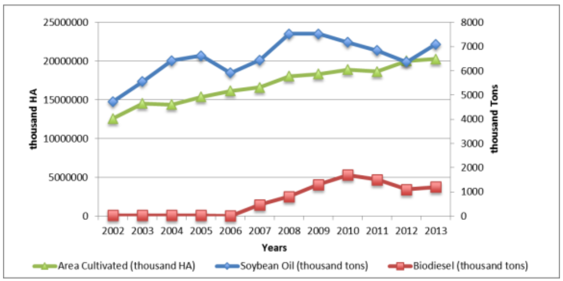

Figure 4 Argentine Soybean cultivated area with regards to its Biodiesel and oil production

New specific energy cops will have a higher risk component since any change in the final market of them will affect in a direct way the farmer.

An important attention must be paid to agricultural policy changes for different kinds of products, there are multiple examples of specific policies that can drastically change cattle or different crops production and this is also in many cases also consequence of climate change conditions in certain years. All his forces are significantly larger than biofuel effects and they are difficult to introduce in predictive models.

In the rich agricultural regions of the Americas, industrialized by the development of the agro-food industries of corn, wheat, meat, cotton, sugarcane and soybean, mechanization is extended and metallurgical engineering is required to serve in the elaboration of agricultural products. Argentina follow specific technological developments, as in the case of the biofuels sector. In Argentina, territories and stakeholders respond to challenges of renewable energy by deriving a part of biomass coproducts into fuels that reduce greenhouse gas emissions and promote a de-centralized energy supply.

It is foreseeable that in the future, biomass increases its participation in energy balances according to international and domestic incentives, in particular because of increasing energy demand. Agro-industrial sectors are adapting themselves and they are innovating in the production of biofuels mainly focusing on residues use. With public policies that supported devices and research networks, and from the good results of the transformation processes of sugarcane and soybean, products which are increasingly competitive, Brazil and Argentina are leading the international markets for bioethanol and biodiesel.

Creativity, large interpersonal relationships and good levels of training distinguish the actors involved in the development of biofuel networks. This is not exclusive of the biofuel alone but is mixed in the whole transforming chain were biofuels are produced. In that sense, in the Argentinean Pampas, or in the Brazil's São Paulo state, integrate this new activity within well established agro industrial sites reflecting the dynamism of the engineers, workers, and entrepreneurs, who are locally entrenched and capable of bouncing into a new economic cycle. They adopt new techno-productive alternatives in the co-construction process of technology exchange and regulation.

The industrial plants responsible for the principal market share of biodiesel are characterized by its high scale and efficiency. Most are located beside the processing complex and ports, which gives enormous advantages from the energy and emitions results. Raw material comes from a radius no larger than 300 km, which also helps to increase efficiency.

In the last years, new bio refineries were developed in order to get higher value products of the biodiesel process as glycerin and sub products. This enlarges the benefits of the chain and increases the countries income. The estimation of 2011 biodiesel complex exports ranges around 19000 million dollars.

3. Logistics:

If the biofuel industry expands from a primarily sugar-based system to a cellulosic-based system, new infrastructure will need to be developed across the countries. The corn-based ethanol system can rely on a well-established logistics process for harvesting, transporting, and storing corn, but many of the feedstocks for the cellulosic process do not have such a robust logistics support framework. The new specific energy crops are also more susceptible to changes since there are no or little alternative markets for the product. On the other hand, while the specific details of every biomass supply chain are different, most of them include a common set of components that are shared in multipurpose crops,

Biomass as a source of energy has to distinguished characteristics: low energy density (amount of energy per kilogram) and high dispersion over the territory. Both severely affects the logistics requirements and cost.

In all cases biomass transportation can be a significant component of the overall product cost, and careful planning and coordination is required to optimize the movement of a low-density, low-cost, widely dispersed feedstock to one or more processing facilities within a given region.

Present commercial multipurpose crops have the advantage that co-products and by-products are responsible for covering significant portion of production cost and the biomass and biofuels can use this advantage toward lowering costs and energy consumption. Depending on the travel distances and the local infrastructure, it may be possible to achieve cost savings with multiple transportation modes (e.g., truck, rail), but this will depend on the specifics of the feedstock origins, processing destinations, and other local conditions, such as infrastructure availability.

All this aspects are increasingly starting to be considered specially when planning the use of specific crops or new residues were a whole logistic transportation infrastructure must be put in place and operate in an efficient manner at all time.

4. Use of residues

The use of residues is being widely promoted as a new source of biomass for biofuel production at large scale using present technologies and second or third generation ones.

There are certain concerns regarding this use without having a systemic view of agricultural systems. Rapid expansion in residual biomass use for all purposes including biofuels and bioenergy is increasing demands on ecosystem resources required to sustain productivity since specific parameters and effects must be studied (fig 5)

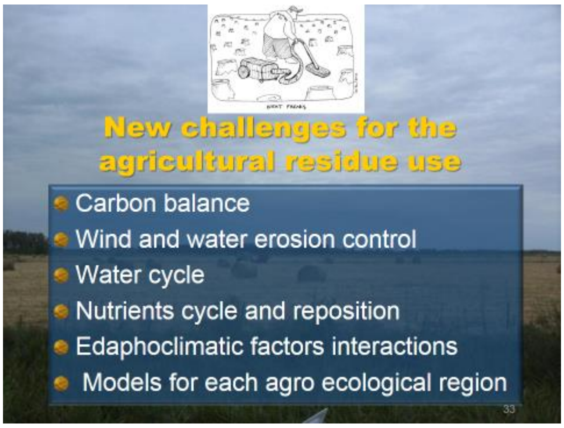

Figure 5 Challenges on residue removal

. Biogeochemical processes and ecosystem sustainability are not well known and research efforts are low in comparison with the knowledge needs. The effects of biomass removal on soil organic matter (SOM) and nutrient storage have been studied, but more information is needed on:

- How different biomass management systems interact with soil types and climate to alter greenhouse gas (GHG) emissions;
- Implications of increasing biomass removal on other biogeochemistry-related ecosystem services;
- How nutrient and C cycles of different crops respond to fluctuations in water availability
- Indicators of soil productivity that could be applied operationally in land management at a site-specific level.

Ecosystem processes-based models are valuable tools for synthesizing biogeochemical cycles and can be used to address environmental and management challenges, and to predict the long-term effects of land use and management practices on soil properties and productivity. This type of approach has been used only in certain countries and there is a great need to confront and adjust them to different soils, crops and climates in order to improve the forecast results.

5. Environmental impact

Since one of the principal drivers, that promoted new legislation regarding the use of biofuels derived from positive implications of their use over greenhouse savings and environmental advantages this has been an aspect under permanent controversy and study. As a well-established method to comprehensively determine potential environmental impacts of a product system throughout its life cycle Life cycle assessment (LCA) has been broadly used. Starting with production and extraction of raw materials, including manufacturing, transport and use, until disposal of residues at end of life (Allen D.T. and Shonnard D.R. 2002) this methodology has been broadly used to study biofuels. LCA is useful to gain an understanding of a product system, to identify the most relevant potential environmental impacts, guide improvement, and for stakeholder communication but this general scope is suceptible to the profesional desition when performing it over a certain feedstock or biofuel. Interest in achieving environmental sustainability for biofuels and bioenergy and inclusion of this aspects in new legislation has provided additional momentum to study biofuel pathways using LCA. Partly in response to policy and regulatory provisions, emissions of anthropogenic (man-made) greenhouse gases (GHG) have been a common feature of biofuel LCA. Examples of this kind of requirements are the United States the Renewable Fuels Standard 2 (RFS2) wich defines a methodology to assess GHG emissions of biofuel pathways, including indirect land-use change emissions of CO_2 The LCA requirements and results are affecting production systems throughout the Pan American region for countries exporting biofuels to the U.S. or to the European Union, through the Renewable Energy Directive (EU-RED). This has already been demonstrated in the Argentina case, where exports of soybean biodiesel have significantly reduced in the last couple of years due to restrictions on GHG emissions as calculated under EU-RED guidelines (Hilbert J. A. and Galligani S. 2014).

Biofuel LCA can be a very complicated analysis and, depending on study scope, may include over 100 unit processes. Aspects of LCA methodology such as choice of system boundary, source of inventory data for unit process inputs, and decisions on co-product allocation can all have a profound effect on study results (Allen D.T. and Shonnard D.R. 2002). Choice of system boundary will have a large effect on study results depending on whether only impacts directly linked to the biofuel pathway are considered (attributional LCA modeling) or whether indirect effects are considered (consequential LCA modeling) (Allen D. T. et al. 2009). Several studies concluded that the choice of method to allocate inventory data among biofuel pathway products and co-products has an overwhelming effect on LCA results (Bailis and Baka 2010; Larson 2006; Wang et al. 2011b).

6. Food security

Food security has been a hard topic on biofuels discussion in the recent years. One of the premises behind this discussion is the positive relation between food production and food security. There is no consideration here on the surplus of food already produced in the world. According to FAO, more than 1300 million tons of food are thrown each year. If we add over nutrition and obesity, we can conclude that today’s production is sufficient to feed the whole world population. Food insecurity and starvation is a very complex issue not solved by an increase in crops yields.
Several studies challenge the perception of biofuel policies having a big impact on agricultural market balances and long-term price developments. (Baffes and Haniotis 2010) point at the fact that worldwide biofuels account only for about 1.5% of the area under gains/oilseeds. Furthermore, in analysing market developments, both authors note that 'maize prices hardly moved during the first period of increase in US ethanol production and oilseed prices dropped when the EU increased impressively its use of biofuels. On the other

hand, prices spiked while ethanol use was slowing down in the US and biodiesel use was stabilising in the EU' (p. 12). More recently the important decrease of soybean oil biodiesel from Argentina (2013/2014) did not affect international grain prices or crop surface. A limited effect was produced on FOB soybean oil prices in the country due to a surplus of this product that found difficulties in finding makets.

During the 2007-08 food price hike, prices of the biofuel substitutes – in particular fossil oil – were rising at the same time. These points to the fact that price rises in energy markets have a strong influence on food prices via rising input costs of farming. There is more to say about the strengthened links between energy and food markets. Baffes and Haniotis (2010) reason that there is a level at which energy prices provide a floor to agricultural prices. The World Bank (2009) reported that crude oil prices above USD50/barrel effectively dictate maize prices, based on the strong correlation between maize and crude oil prices above that price and the lack of such a correlation below that price. Baffes and Haniotis examine the energy/non-energy link, investigating among others six food commodities, and find that energy prices explain a considerable part of the commodity price variability... Next, the authors find that food commodity prices respond to energy prices by moving in a very synchronous manner, indicating that analysing food markets requires an understanding of energy markets as well. The authors also conclude that agricultural commodity market fundamentals appear, in the short term, to be playing somewhat a lesser role than in the past, tending to be overshadowed by the much stronger pull of energy prices.

The discussion has addressed the impact of biofuels on food prices, which determines the price and is therefore a central factor in the accessibility of food to poor consumers. There is also a possible relation to be explored beyond food prices in relation to overall inflation. In countries that depend heavily on imported fossil fuels, oil price rises will give upward pressure on inflation rates – as indicated by rising consumer prices index CPI. The development of a substantial domestic biofuels supply will, under such conditions, help to ease price inflation pressures. In theory, this may help to stabilize consumer purchasing power and the stability of access to food of poor consumers.

Effects on multipurpose crops price increase may have positive impacts in technology use and yield increase. In some crops as the food component is much greater than the fuel a positive effect of bioenergy production on food production could appear. The processor may well exert a strong influence on the crop choice and the scale of operation used for production. Relative production of product may vary according to different external forces as domestic and international policies (Fig 6) Private investors could favour large-scale production because they entail lower production costs.

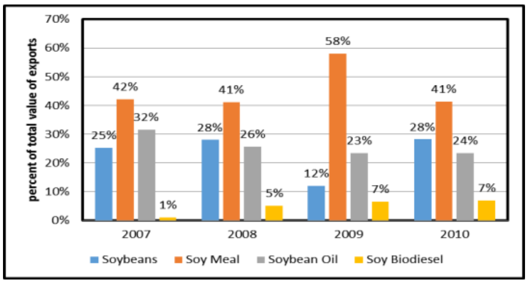

Figure 6 Different products production Source: Author’s elaboration using information from INDEC/CIARA

While promoting biofuel production may have strong distributional effects, biofuel developments may contribute to an overall improved macroeconomic performance and living standards. This is because biofuels production may generate growth linkages (i.e., multiplier or spill over effects) to the rest of the economy. A good example can be found in Argentina were export tax over biofuels are distributed between the whole society. Finally, there are macroeconomic linkages through which biofuels may stimulate economy-wide growth. For example, biofuels exports can relieve foreign exchange constraints, which often limit developing countries’ ability to import the investment goods needed for expand production in other sectors.

The pathways for food security impact of biofuels and biofuel policies cover price effects, income effects and macroeconomic effects. Key underlying mechanisms relate to the allocation of available land of different qualities over its possible alternative uses, and to the impact of biofuels on the energy or fuel balance in the production country. In order to evaluate the full impacts and trade-offs of biofuels production on food security, a framework is needed that captures the direct and indirect or economy-wide linkages and constraints at the macro- and microeconomic level (FAO 2010). The economic method specifically designed to capture these impact pathways is known as “computable general equilibrium” (CGE) modelling.

A particular strength of CGE modelling is the capacity it provides for a consistent analysis across related economic systems that share or compete for resources such as land and investment capital. Although this tools are well oriented there is a lack of information regarding field data on real impacts of biofuels in other markets and most models rely on old data relations that need to be confirmed. For biofuels and food security analysis, the interaction between the food and energy systems is pivotal. Global CGE analysis will allow analysis of energy and food price developments worldwide, which is important when comparing market interventions that will have implications for the global biofuel or agricultural markets. In contrast, a CGE analysis at the country level may allow a more in-depth examination of the cross-sector repercussions of demand and supply changes in biofuels, with often more attention on the distributional impact.

We should stress out the need of deep studies focusing on the relation between different products end use of the main feedstock is used in the world today examples

Sugarcane sugar bioethanol bagasse use for energy

Corn DDGS DGS bioethanol

Soybean soybean meal fiber pellets oil biodiesel

Models that predict future effects rely on previous history experience and they confront difficulties in imaging new changes as food patterns and behavior and policy movements.

7. Biofuel complexity

If we make an analysis of the principal biofuel production in the world, we find out several common features in all of them

- They derive from well-established transforming chains (food, fiber, feed etc.)
- They come from coproducts or residues from agriculture and agroindustrial transformation
- Rely on logistics and size economy savings already established.
- They produce multiple impacts in established markets generating new products, price movements, replacements, food feed patterns etc.
- Much affected by policy and administrative changes inside and outside country boundaries
- The industry were commodity transformation occur has great plasticity to move from biofuels into other food feed products according to domestic and international prices and conditions

Soybean is a good example of the relative low weight of the biofuel component in the whole value chain. The common sense given the size of biodiesel market is the latter, but the growth of alternative energies based on food commodities has been mentioned as one of the determinants for both food production and price growth. A first point against this hypothesis is the size of the market as mentioned. In Argentina's case, the world leading soy biodiesel exporters since 2009, the weight of that fuel in the value of soy-based exports is marginal.

8. CONCLUSIONS

- Looking at the different relations between food.feed.fuel markets and the multiple implications of multipurpose and specific crops there is an urgent need to increase research over real markets.
- Recent history covering policy implementation and change, growing production of biofuels and food give plenty of field data to improve the understanding of complex relations between markets.
- Models results should be confronted with real markets behaviour in order improve the understanding of possible impacts of different types of crops and biofuels technologies.
- Punishments and promotions should be based on reliable data rather than future predictions since big mistakes could be made.
- New studies should be made over first and second generation biofuels with the same kind of methodology in order to study the multifactor effects of them.

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1. LOGO SPACE