GHG emission reduction and energy production in agriculture, forestry, aquaculture and mariculture: potentials and impact

Hans Langeveld[a], Catherine Macombe[b], Philippe Roux[c]*

[a]WUR, Plant Research International, Wageningen, The Netherlands; [b]CEMAGREF, UMR Métafort, Aubière, France; [c]CEMAGREF, UMR ITAP, Montpellier, France - Hans.Langeveld@wur.nl

Setting the scene

Europe is facing important challenges, including Global Warming or Climate Change. Agricultural, forest and aquatic production systems (sea and coastal zone systems included) play an important role in both the cause as well as the solution of this problem. They can be responsible for emissions of Greenhouse Gases (GHG) and can help to decrease CO2 concentrations, either by directly reducing GHG emissions in production processes, or indirectly by producing biomass that can replace fossil fuel applications in heating, electricity production or transportation. Elaborating and implementing solutions for Climate Change could be an opportunity for rural land users, provided that research and extensions can help them to realise their potentials. The problem is not calling for a revolutionary shift nor for one-way solutions, but, in stead, for a mosaic of good practices and ideas.

What is the current state of art? Not counting what he/she drinks, a citizen of the European Union eats 700 kg of food every year. He uses about 150 to 200 litres of water a day for his domestic needs but also through the industrial sectors. He uses about 10 kilos of oil equivalent per day (10.6 in 2000 in the European Union of 15 Member States and 9.7 kg in 2005 in the EU of 25 Member States, (Eurostat, 2007), three quarters of which are fossil fuels (oil, gas or coal). We argue that the European Union will probably maintain its self-sufficiency in food and water (Euractiv, 2007 a,b), and even attain it in energy for heating and electricity (Wingert, 2005). But we show that, as knowledge stands at present, things are otherwise for fuel self-sufficiency (Agency E.E., 2006; Edwards *et al*., 2007; VVT RE1 2007). The most serious pathway for replacing fossil fuels is to produce fuel oils from biomass; these are called biofuels. They are said to be 1st or 2nd generation depending on both the type of material and the conversion method. For 1st generation biofuels, most of the biomass is from food crops (corn, sugar beet, palm oil, rapeseed, sugar cane). A recent assessment (Crutzen *et al.,* 2007) shows that N2O release from the 1st generation biofuels'production may negates global warming reduction. Investigations from the International Water Management Institute (De Fraiture *et al,.* 2007) tend to demonstrate that pursuing them in water short countries turns green energy into a blue threat by worsening water scarcity. Some papers (de Vries *et al.* ; Langeveld *et al.* ; Kägi *et al.*) add some answers to the question of biofuels interest for fighting against Global Warming. The main so-called 2nd-generation biofuels could be obtained from a very wide spectrum of ligno-cellulosic biomass, ranging from the whole plant through to non-food farm residue or 'woody' sources (straw, timber, woodchips, and dedicated crops such as algae (Rengel), Miscanthus (Kägi *et al*.), Arundo, Reed Canary Grass, etc.). Anyway, wood will remain a direct source for heating too.

First, let us assume that no fundamental discovery in terms of energy production and/or storage has been made. As for the relation to time, we are looking at things in the "energy transition phase beyond peak oil" and we are thinking about the impact on land and water uses according to our assumption of a huge reduction in transportation. During this transitional phase, a significant proportion of electrical energy will still be nuclear (Uranium peak different from oil peak: resources estimated by IAEA and WNA 30-60 years). Nevertheless, a significant share of the electricity produced, as well as that for heating, will be derived from a set of renewable energies closest to the place they are consumed: geothermal, solar, hydraulic and wind energy, but with the exception of biomass, because any biomass that can end up in a biofuel plant (crops, short rotation coppice, forest slash, industrial and household waste), without competing directly with food, would be earmarked for that purpose as a priority. Transportation methods that are unable to use electrical energy will consume these biofuels.

On the livestock-breeding front, monogastric animals will be gradually restricted to eating mainly household waste (current domestic livestock breeding in North Africa and China is already an example) and to limited sources of co-products (oil cake, pulp, molasses, etc.) that are not easy to recycle effectively into biofuels. Current chicken chain assessment (Usva *et al*.) highlights the dilemma of monogastric animals' production when energy is sparse and GHG emissions have to be avoided.

Ruminant breeding, preferably for milk production, will use land (grassland, steppe, undergrowth, etc.) where the biomass cannot be harvested for biofuels through lack of sufficient energy efficiency. Some technics may contribute in lowering the environmental drawbacks of cattle, like when spreading animal wastes (Pradel and Thirion) or producing sheep meat (Benoit and Laignel).

The basis for everyone's diet will still be plants (cereals, fruit and vegetables) as it is today, with limited quantities of milk and eggs, and very small quantity of meat, a product that will have become a luxury everywhere. Two simulation tools provide interesting insights about GHG at the whole farm level, for mixed crop and cattle farms in Japan (Hayashi and Kato) and in France (Fiorelli *et al*.).

The need to reduce transport will shape new agricultural areas: re-territorialisation of food production chains; conquering new land or recovering deserted areas; dividing up the land between food use, energy use and other uses. Food chains will "retract" around the places where the basic food is produced and will need to be optimised (nowadays, 25% to 40% of the food is lost during the process (Schneider 2007)). This also means that the foods made up of a combination of several foodstuffs will have a very limited place in this world where easy transport is hard to come by, as will frozen foods that consume a lot of energy. All the heavy foods (laden with water) will be distributed nearby as a matter of priority. Cheese and cereals will be consumed further away from their production area besides. As for imported foods, they will once again be as rare as they had ordinarily been for thousands of years. Traded goods will be transported by sea preferably; this has always been the most efficient form of transport (Debeir *et al.*, 1986). Around the towns, land that is not currently used for farming will be redeveloped for agriculture, and shallow waters will produce food and may be biofuels thanks to mariculture (seaweed, shellfish, minerals, etc.) (Brandenburg, 2006). New territories, that it is not worth using today for livestock breeding (Patagonia, deserts, etc.), will probably have to be rehabilitated. Rural areas will still serve as support for food, for biomass production and for their water-filter functions. With the result that in a given place, land suitable for cultivation will, according to its agro-climatic potential, produce specialised crops for human food, or biomass for energy depending on the location of the closest biofuel plant and on the distance to towns. A Portuguese case study (Borrego) illustrates this shared space. Livestock rearing land will be restricted to the sites where neither biomass that can be converted into biofuel nor food can be cultivated, and to the grassland serving as water filters that can only be used for grazing. All these trends may be sum up at the farm level, by describing the sustainable farm of the future.

This future rural landscape is contingent upon the coming attitudes, concerning the so-called field of "Sustainable Consumption and Production". Will the farmers adopt the new cultures, the new techniques (Defrijn *et al*.), with the adequate institutions? Are the new industries developing towards biofuels use (Mark Cho and Nettleton) as well as towards new food adoption (Mikkola and Risku-Norja)?

In WS5, nearly all the authors needed to assess the GHG emissions or the energy consumption of one farm, one industry, or one territory. And nearly all the methods are rooted in the spirit of the Life Cycle Assessment (LCA) methods. It is not useless therefore, to wonder whether LCA may be used for such topics (Benoist A. *et al*.), as it was born first for industrial purposes.

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