Keynote address

Innovation: Key to future agri-food production

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World food security must be attained, despite emerging issues and major challenges mentioned in this paper. But this will depend on major investment in technology and innovations. Highly productive agriculture is needed; particularly indispensible are productivity increases per hectare and per animal. Above all, worldwide partnering is essential if we are to address the challenges of today.

Agri-food priorities in the Netherlands

The Netherlands is the second largest food exporter in the world. It is a small densely populated country (16 m people, 41,000 sq km) and hence the country's two major agri-food sectors, horticulture and livestock (dairy, pork, and poultry) are characterised by being very intensive and highly productive. The Netherlands has created significant competitive advantage by virtue of having several major food and agribusiness companies including: Ahold (food retailer); DSM (food ingredients); FloraHolland (flowers); FrieslandCampina (dairy); Greenery (vegetables); Nutreco (animal & fish feed); Unilever (food); Vion Food Group (pork, beef); and a large seed industry (such as Rijk Zwaan).

The Netherlands has also made 'flowers and food' one of its four key innovation areas and has established a joint innovation platform based on the 'golden triangle' model – of research, government, and industry working together. The outcome is the Food Valley centred around Wageningen University and Research Centre (Wageningen UR) and industry partnerships supported by the Food Valley Organisation.

Emerging issues

Major emerging issues in the food and agriculture sectors are as follows:

- Foods adversely affecting health.
- Food quality and safety, including zoonoses.
- Sustainability and productivity.

Health issues and diseases linked to the quality of nutrition include cardiovascular disease, diabetes, cancer, asthma, allergies, inflammatory bowel disease, and of course obesity. The societal costs in the Netherlands of these conditions amount to approximately 5 billion €/year.

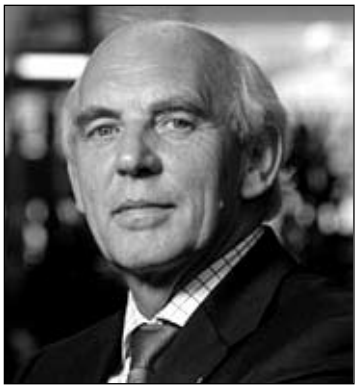
The issue of food quality and safety is another major issue, especially with increased incidence of food allergies and intolerance. It has led to an increasing demand for tracking and tracing technologies such as radio-frequency identifications (RFIDs)[1], biosensors and increasingly sophisticated methods of analysis. A related driver is humane animal production.

Sustainability and increasing productivity is a global issue touching on practically all aspects of the food production and value adding chain. It includes the often conflicting drivers of increasing production per hectare (and per animal), reducing the environmental impact, using biomass for bio-fuels, and keeping good food affordable to the widest possible population given rising costs of raw materials, energy and water. Green chemistry and efficient treatment or use of waste streams is a rapidly growing global industry.

Future perspective

A strongly growing world population (see Figure 1), increasing income per capita and enormous increase in demand for high-quality protein is beginning to put some strong drivers on the food and agriculture sectors and will continue to do so. The demand for food is estimated to increase 50% within 20 years and double within 40 years, with a strong increase in demand for animal protein. An important question to be addressed is

[1] *Radio-frequency identification (RFID) is the use of an object (typically referred to as an RFID tag) applied to or incorporated into a product or animal for the purpose of identification and tracking using radio waves.* (Editor)



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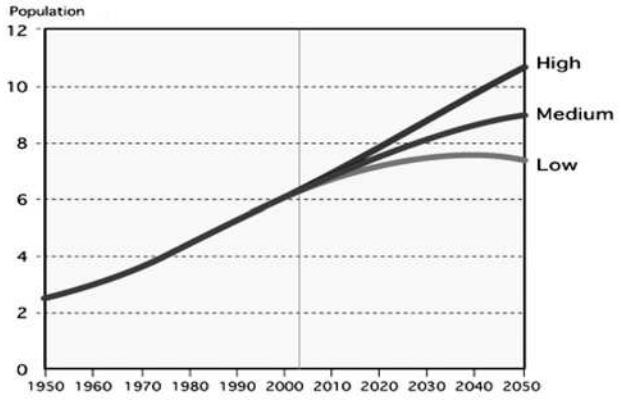


Figure 1. United Nations World Population Projections 1950–2050.

whether or not agricultural production and food supply can keep pace with this demand, given the already impending constraints on fresh water, fertile land, and renewable energy. The problem of food consumption is one not only of quantity but also quality in terms of calorific oversupply (causing obesity) and the undersupply of protein, particularly high-quality protein.

The industry faces four major challenges:

- Increase production per hectare (and per animal),
- Improve food quality and food safety,
- Decrease the environmental impact of the food chain,
- Use biomass for biofuels and green chemistry (renewable resources).

These challenges will require new knowledge and breakthrough technologies.

Given these predictions, two major related issues are the increased attention on access to fresh water supplies, and increasing concern over the pace of anthropogenic climate change. Food and agriculture already consume an estimated 75% of the planet's total readily available fresh water. Increasing food and biomass production by 50–100% over the coming decades in order to meet demand is almost certainly going to exceed the spare capacity.

Improved breeds of animals and plants will be required, together with more efficient production systems. Animal protein requires much more water per kg production than plant protein. Ways to extend animal proteins with plant proteins could help improve the water efficiency of new foods without limiting the supply of quality protein. Other breeding or genomic improvements in plants and animals should include greater disease resistance, feed conversion, fertility and longevity. Such major improvements require international collaboration, and two examples which Wageningen UR are involved with include the Centre for Photosynthesis Research, and the Centre for Biosystems Genomics, focused on genomics for sustainable, safe and healthy plant production.

At the same time, in response to the increasing global concern about climate change, significant policy has been put in place across Europe with respect to the carbon footprint of foods in terms of transport, cooling, packaging, etc. Recent life-cycle analysis studies comparing intensive production systems with less intensive and ecological farming systems has shown that intensive systems turn out to be the most efficient:

- Lowest 'footprint' per kg of product (reviewed by De Vries & De Boer 2010):
  - key factors in animals: feed conversion, number of offspring,
  - common farming system better than ecological farming.
- Lowest demand on space and on nature (Glendining *et al.* 2009).
- Differences in carbon footprint between meat and modern vegetarian diets smaller than commonly expected (Blonk Environmental Advice & Wageningen UR 2010).

Further analyses comparing current dairy farming resource requirements with those of 50 years ago also provide support for innovative highly intensive farming (Capper *et al*. 2009). Compared to 50 years ago, the following percentages of each input are now required per kg of milk: 10% of land, 21% of animals, 23% of feed, and 35% of water.

Moreover production results in: 24% of manure, 37% of CO_2, and 43% of methane.

Innovations needed

A range of innovations will be needed to meet the increased demands for sustainable production. Some examples are:

- precision farming (using GPS-machinery and individual-animal sensors) which will contribute to increased production, reduction of environmental impact, improved traceability, improved food quality and safety and increased profitability and sustainability;
- decision-support management;
- new housing systems for better animal welfare;
- animal health control (particularly of zoonoses);
- new food technologies, leading to more nutritious products, healthier diets and reduced wastage;
- intelligent cooling, transportation and storage;
- sensor-based quality control and packages;
- bio-refinery to use (waste) ingredients for other purposes (see Figure 2).

In response to global demands for sustainable energy and materials previously provided from fossil fuels and other non-renewable resources, a new biomass value chain has emerged. This is shown in Figure 2. Of particular importance is the conversion of by-products and wastes to valuable biomass.

Strategic and structural changes at Wageningen UR

In the 1990s Wageningen University reassessed its situation: student numbers were declining strongly and the complexity of many surrounding separate research institutes did not provide the cohesive effort that uniting under one organisational umbrella could offer (see new structure in Figure 3). A common position and strategy was developed with all stakeholders and this led to the unifying concept of the agri-production chain integrated with the living environment in all its aspects, plant, animal and human.

As a result Wageningen UR was established in 1998. It was founded on the three pillars: Wageningen University, Van Hall

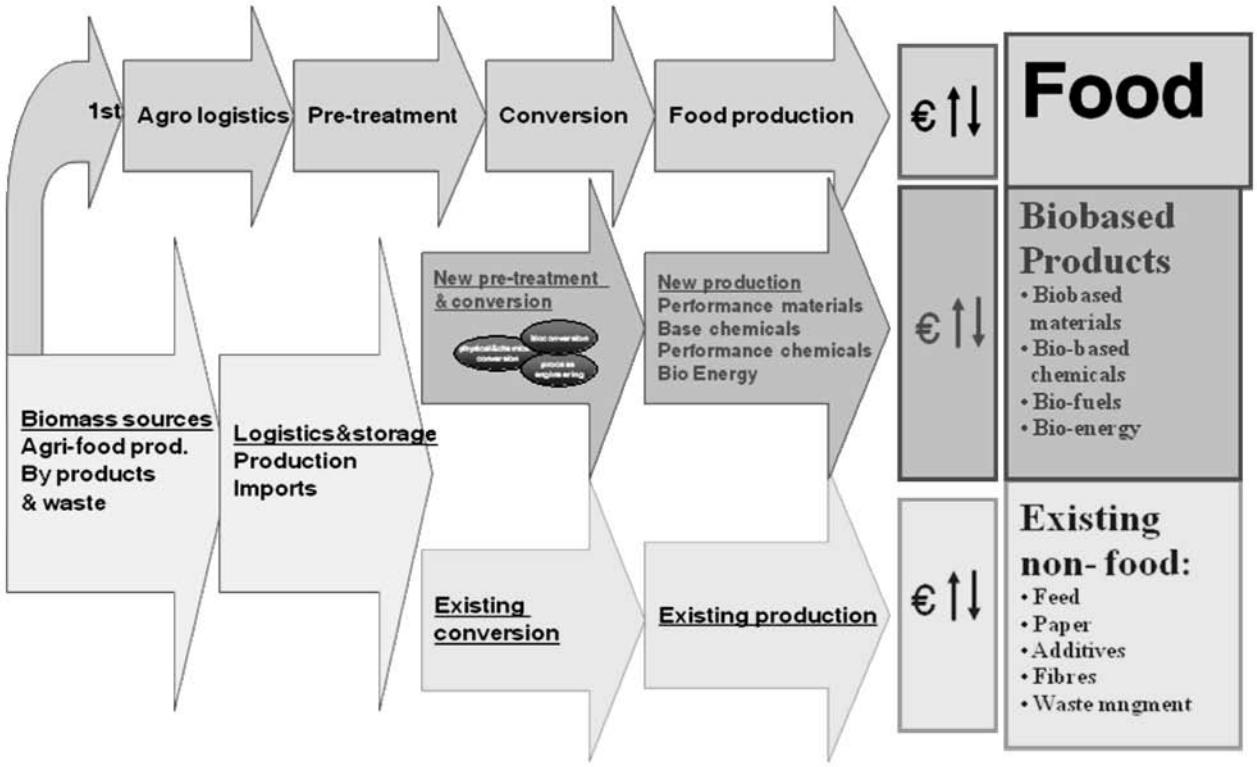
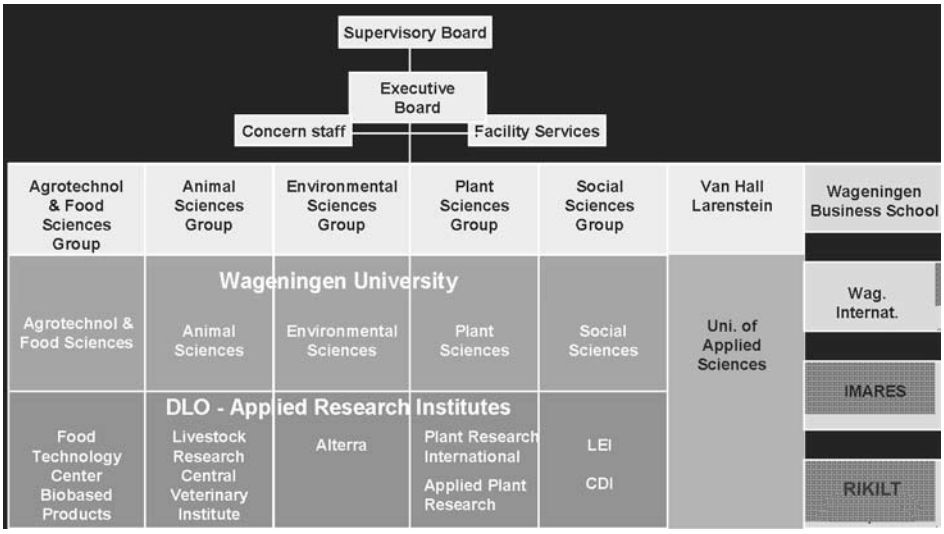


Figure 2. The new biomass value chain.

Figure 3 Wageningen UR organisational structure.



Larenstein University of Applied Sciences, and Dienst Landbouwkundig Onderzoek (DLO) comprising the nine Applied Research Institutes (40 locations in all, including one in Brazil and one in China). This structure aligns to the stated domain of *healthy food and living environments, including the entire food production chain*. The total organisation now has a budget of 675 million €/year, employs 6500 staff, teaches 10,000 BSc/MSc students and 1400 PhD scholars from more than 100 countries. The numbers of students are increasing rapidly.

The Food Valley concept

The mission of Wageningen UR is to explore the potential of nature to improve the quality of life and in following this it has developed an extensive international network. Wageningen UR is also a key and active partner in the Food Valley (see Figure 4). The Food Valley concept is an open innovation cluster comprising major food and agro companies, research institutes, experimental facilities, innovative clusters (e.g. genomics), incubators and science parks, and the network organisation called the Food Valley Organisation.

Success factors for the Food Valley are:

- 'Golden triangle' of business, universities/ knowledge institutes, and government.
- Business leadership.
- Short communication lines and transactions.
- Full commitment to true partnership and sharing risk and reward.

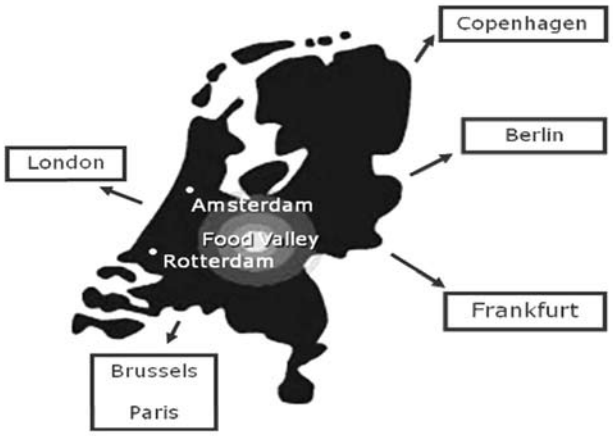


Figure 4 Food Valley as a concept.

Wageningen UR's worldwide partners on global food issues include:

- INRA (Europe)
- Embrapa and University of São Paulo (Brazil)
- INIA and University of Chile (Chile)
- CAAS, various Universities (China)
- University of California, Davis (USA)
- Massey University (NZ): Proteos (Novel Approaches in Sustainable Protein Supply) – project under development with Riddet Institute
- Active partner in the Global Research Alliance on Agricultural and Greenhouse Gases

Conclusion

New initiatives will be needed if world food security is to be attained. These initiatives will involve major investment in science, technology and innovation, and worldwide partnering. Innovations will include novel crops and animals, replacements for animal-based foods, precision agricultural production and balanced global nutrition. Highly productive agriculture per hectare and per animal is indispensible in a resource-constrained future.

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