Main drivers in agricultural research and education to secure food supply and assure sustainability

Mínguez M.I., Connor D.J.

in

Romagosa I. (ed.), Navarro M. (ed.), Heath S. (ed.), López-Francos A. (ed.).
Agricultural higher education in the 21st century : a global challenge in knowledge transfer to meet world demands for food security and sustainability

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 113

2015
pages 23-26

Main drivers in agricultural research and education to secure food supply and assure sustainability

M.I. Mínguez and D.J. Connor

Research Centre for Agricultural and Environmental Risk Management
Technical University of Madrid (CEIGRAM-UPM),
C/ Senda del Rey 13, Ciudad Universitaria, 28040 Madrid (Spain)
and The University of Melbourne (Australia)
e-mail: ines.minguez@upm.es
djconnor@unimelb.edu.au

I – Introduction

The growing world population, 9.8 billion by 2050, and increasing affluence are placing ever greater pressures on agriculture to feed the world well (a 70% increase in production is projected) while conserving as much of natural systems and their resources as possible for other purposes. The result is a focus on (ecological or sustainable) intensification of agricultural production, i.e. the greater inputs of science and technology needed to produce more crop and animal products per unit area per year while restricting deleterious off-site impacts of agriculture, including emissions of greenhouse gases (GHG).

Markets will always play a fundamental role in food security notwithstanding that price volatility that was at the base of the food crisis of 2008, could happen again. Farms which are the production units must be sustainable, and their sustainability relies on economic, social and environmental performance.

There are no magic bullets. Agricultural production is a stoichiometric process. The harvesting of grains and meat extract nutrients from soils and must be replaced for continuing productivity. The solution to intensification is found in more and better scientific understanding of agricultural production and technological applications as aids to management. For high productivity, crops and flocks need continuous attention to growth and reproduction and to the control of pests and diseases that are the greatest threat to productivity. External thermal environments cannot be improved for crop and animal growth so success is found in selection and management of adapted farming systems. Water shortage is a common limitation to productivity in many regions. Globally, crop (arable) land amounts to 1500 Mha of which just 300 Mha are irrigated. The scope for expansion of irrigation is limited because both land and water resources are fiercely contested for other uses.

The greatest challenges for greater productivity are found in Asia and especially in Africa where the human population is growing fast enough to overwhelm the reductions that are occurring in many European countries. Many African countries currently rely on food imported from the major food producers (USA, Brazil, Argentina, and Australia) to meet their food requirements. The potential for such export may ultimately be inadequate but will certainly require increasing contributions in the short term. Africa, with its dominance of self-sufficient farmers and growing urban populations, faces an enormous challenge for the development of sustainable agriculture to provide more of the required food for urban dwellers and to sustain the environment and the livelihoods of farmers.

This paper deals first with the changes that intensification places on agricultural production and then focuses on drivers for change in research and agricultural education in developed countries, drawing on examples from Europe and Australia. It then discusses tertiary education structures required to produce graduates able to assist and service these changes and continue their development. The discussion is conditioned by the trajectories of change currently underway in agricultural production, supporting technological developments and post-farm processing to meet market demands.

II – Drivers for change in agricultural production systems

Because there is little new land for cropping, greater production can only be achieved by breeding for higher yields and disease resistance in crops and animals and/or by more intensive use of land, including more crops per year. This must be done with respect of the environment and hence the increasing use of the terms “ecological intensification” and “sustainable intensification”. At the same time increasing knowledge and advances in sensors, electronics and communication are allowing more efficient and timely management by mechanized and automatized interventions in agricultural production systems

Thus drivers can be listed as follows:

- Large increases in productivity require more efficient production that in turn may require large-scale production units that seek more efficient use of inputs to produce safe products of required quality by applying farming methods that are ecologically sensitive.
- Substantial investment is required to develop these production units and is achieved by amalgamation of, or cooperation among, existing smaller production units and major investment in infrastructure. This is being achieved in Australia, for example, by local and overseas investors.
- Agricultural enterprises and agribusinesses require a wide range of employees ranging from unskilled labour through to highly qualified and experienced academic researchers.
- The main driver for change results from the opportunity offered to entrepreneurs among current and new farmers to supply the needed 70% increase agricultural production.
- Food chain value. The connection between agriculture and subsequent processing for consumption will be increasingly vertically integrated (diminishing waste). Much processing will be done on farm (or close by) so that enterprises obtain benefit from selling value-added products.
- Most population growth will occur in Africa and Asia but the major increases in productivity to 2050 will be led by current major exporting countries, USA, Brazil, Argentina and Australia (will Europe intensify in order to export? see below).
- FAO estimates that small-scale farmers produce over 70% of world food needs and that 70% of people currently living below extreme poverty (<1$ / day) are in rural areas. Their problems will not be solved by intensification of agriculture only. Policy, social, and economic measures will be required to assist small scale farmers adapt to technology and contribute to the food security of rural and urban dwellers.

How will Europe attend to the increasing world demand for food?

Currently Europe supplements its own production with that from ca. 50Mha of overseas "traded" land (Von Witzke, H. and Noleppa, S. 2010) to meet overall food requirement. It does this while maintaining many inefficient small farms with subsidies and encouraging low productivity systems such as organic agriculture and crop production for biofuel. Will increasingly expensive imports cause a change in attitude or will food costs rise to whatever is needed for importation in competition from increasing demand from developing countries. Does Europe want to contribute to greater food production and diminish its quota of "traded land"?

III – Changes to agricultural production systems

By extrapolating current trends the following key features of developing production systems should be highlighted:

- Production, especially of staple foods, will be dominated by large, often integrated, agricultural enterprises covering large areas of field crops, orchards or pastures for grazing animals. Much animal production will be increasingly intensive (poultry, pigs, dairy) conducted in closed environments with fodder harvested from adjacent or far away large areas (distance will depend on product and transport prices), or provided more widely by contract growers depending on product and transport prices.
- Many smaller farms will remain to meet local needs and/or provide specialist products, e.g.: organic and others with premiums for local authentication.
- For all food products, society will demand safety and environmental sensitivity of production methods. Given that, consumers will select products on the basis of price and quality.
- To meet these requirements and consumer preferences, agricultural enterprises will need to be efficient (economically and environmentally – "Climate Smart Agriculture"), apply modern technologies, establish close integration between production activities for efficiency and reduce waste, especially evident in joint crop-animal operations.
- The key feature of agricultural production will be increasing application of science and technology, management by measurement, recording, and analysis of activities and inputs, and consequent traceability of all products by production steps to points of origin.
- The connection between agriculture and subsequent processing for consumption will be increasingly vertically integrated. Much processing will be done on farm (or close by) so that enterprises obtain benefit from selling value-added products.
- Risk management. Agricultural insurance and farm safety nets are tools for sustainability.
- Small-scale farming including subsistence agriculture will need specific support from socio-economic and technical extension services to evolve and organise themselves into a local or global market.

IV – Consequent requirements of the educational system

This view of agriculture of the future leads to specification of the educational requirements of staff to sustain and develop it. There are three groups:

- Graduates with technical qualifications to maintain and monitor production and processing systems. This demands an understanding of the basic crop and animal production systems, including health and sanitary issues. Also the principles of operation of measuring equipment, and the nature and significance of the parameters that are measured - These are the shortest courses and can be completed in 3 years.
- Masters graduates or "Engineers" to design and manage (large) agricultural operations with complex infrastructure, including internal measurement systems, developed for individual enterprises – There is a wide range of specialization here but with a common understanding of the soil-plant-environment and socio-economic interactions involved in both design and management, together with environmental issues consequent to production. The need for strong basic scientific and socio-economic education both before and together with applied disciplines makes these courses longer than those for technicians. A common solution is to include a post graduate masters program for specialization. The linkages in the complete food change from "farm to fork" will more closely integrate primary production and food science. A three-plus-two year program is common.
- Research Scientists (doctorates) to resolve immediate problems, improve current processes, and design new ways to achieve current objectives, improve crop cultivars and animal strains for higher productivity and resistance to stress and disease production, discover ways to provide new products, and resolve off-farm (and factory) environmental issues. The current system of formation of research scientists is likely to continue but with new specializations determined by changing scientific capabilities. Even so, training should produce researchers who can apply their training more broadly than in the inevitably specialized research projects by which they obtain their qualification. Doctorate programs last an additional 3 years or so.

V – General principles for design of agricultural education

- Science, technologies, and social sciences are the fundamentals of any agricultural degree. The unifying factor in the early years of courses to educate for the first two levels must be common subjects at appropriate levels in biology, chemistry, mathematics, and socio-economics. In this way, students will have a sound basis for the specializations they choose and a level of basic knowledge that allows them to adapt to changing technology and specializations throughout their career.
- Critical thinking and analytical capacities for graduates will have to be built all the way through their courses.
- There is also the question of flexibility for movement of current students or graduates between the three levels described above. The major issue is probably for students studying technical courses, or graduates, to move to master/engineer level. Second, the selection of candidates for doctoral programs. The proportion of such students or graduates seeking transfers may be small but course structures should cater for transfers.
- Finally for graduates at all levels there is need for continuing education that educational institutions and professional societies can share and that professional societies can regulate.

Reference

Von Witzke, H. and Noleppa, S. 2010. EU agricultural production and trade: Can more efficiency prevent increasing 'land-grabbing' outside of Europe? Humboldt Universität zu Berlin, 40 pp.