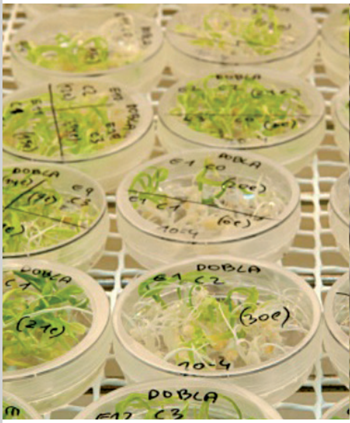
Agricultural Higher Education in the 21st Century

A global challenge in knowledge transfer to meet world demands for food security and sustainability

Edited by:
I. Romagosa, M. Navarro, S. Heath and A. López-Francos



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Le Centre International de Hautes Etudes Agronomiques Méditerranéennes (CIHEAM) a été créé, à l'initiative conjointe de l'OCDE et du Conseil de l'Europe, le 21 mai 1962. C'est une organisation intergouvernementale qui réunit aujourd'hui treize Etats membres du bassin méditerranéen (Albanie, Algérie, Egypte, Espagne, France, Grèce, Italie, Liban, Malte, Maroc, Portugal, Tunisie et Turquie).

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Agricultural Higher Education in the 21st Century.

A global challenge in knowledge transfer to meet world demands for food security and sustainability

Editors: I. Romagosa, M. Navarro, S. Heath and A. López-Francos

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Session III: Addressing the needs and challenges for innovation in Agricultural curricula

Session IV: Globalization and International Alliances

Foreword

The world population continues to grow at about 1.5% a year. The projected figure of 7 billion for last year was reached and the UN statistics are pointing towards 8 billion for 2020. In addition, emerging world economies are undergoing significant changes in their diet. In the forthcoming decades we will therefore have to double our food production on less land per capita, with less water, often under limiting and highly variable environmental conditions.

Today in most developed countries, farmers are ageing and new generations of students are not attracted to agricultural studies. This is an alarming issue in the OECD countries, where agricultural knowledge is advancing significantly, yet not being transferred via the higher education system at an equal pace. The lack of understanding between agriculture and society as a whole is a concern for the higher education community, which has to reflect on how to improve the image of agriculture and to make it more realistic and attractive to the modern-day urban population. In the non-European Mediterranean countries, as in most other developing countries, high school graduates are still interested in agricultural studies. However the common challenge now consists in finding a way to complement classical agricultural education with new and emerging techniques, and in training graduates to enable them to promote a sustainable agricultural development in complex socio-economic and environmental contexts.

A major question we all face is how to manage the sustainability of the agricultural systems; agriculture undoubtedly needs to increase its productivity while securing the sustainability of the agro-ecosystems. We have to improve the agricultural knowledge transfer system and adapt it to these goals, including new strategies, techniques and incentives to encourage the introduction of production systems and emphasize long-term sustainable goals.

The International Conference "Agricultural Higher Education in the 21st Century – A global challenge in knowledge transfer to meet world demands for food security and sustainability" was held in Zaragoza (Spain) from 15 to 17 June 2015. It was organised by the Mediterranean Agronomic Institute of Zaragoza of the International Centre of Advanced Mediterranean Agronomic Studies (IAMZ-CIHEAM), the Union for the Mediterranean (UfM), the Association for European Life Science Universities (ICA), the Global Confederation of Higher Education Associations for Agricultural and Life Sciences (GCHERA) and the Centre for Agricultural Research of the Hungarian Academy of Science, with the collaboration of the OECD Co-operative Research Programme on Biological Resource Management for Sustainable Agricultural Systems.

The aim of the conference was to convene top-level experts from different areas of the world to hold a discussion and propose recommendations for the future development of curricula in Agriculture and Life Sciences to face current global challenges for food production. The Conference related to agriculture in its broadest definition, namely the food and non-food value chains relating to agriculture, forestry, food and natural resources, with due regard to rural development and the environment. A lively debate took place around this large area of education, among more than 80 persons attending the conference from 28 countries across the world, to exchange ideas and views on questions such as:

- What contributions can higher education make towards facing the global food challenge?
- What went wrong in higher education for it to lose its former power to attract generations to study agriculture? How can we encourage the new generations to study agriculture?
- What kind of teaching is needed to transfer the latest technologies and to fulfill societal demands for food systems? For example, how can Higher Education cover the goals of today's precision agriculture, or support the "from farm to fork" paradigm?

- To what extent and how should soft skills, as team working, entrepreneurship, communication or problem solving, should be reinforced?
- What kind of new communications are needed to pursue societies and decision-makers on the importance of agriculture for our sustainability and for our future?
- How can internationalization help training respond to common global challenges with local solutions?

This issue of Options Méditerranéennes publishes de Proceedings of the Conference including a summary report on the Conference and its conclusions, and 22 articles by the invited speakers, structured in 4 sections: (I) Challenges for agriculture in the XXI century; (II) Are current agricultural educational models suitable to meet global challenges?; (III) Addressing the needs and challenges for innovation in agricultural curricula; and (IV) Globalisation and international alliances.

We would like to acknowledge the speakers of the Conference and the authors of the articles for their excellent contributions, the reviewers of the papers, and all the Conference attendees for their active participation during the debate, and their valuable inputs for the Conference conclusions, as well as all of the institutions involved in the organisation of the Conference. Special thanks go to OECD for its support and to the Diputación General de Aragón for kindly offering the use of the magnificent medieval Palacio de la Aljafería in Zaragoza for the tourist visit and the Conference welcome reception.

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Agricultural Higher Education in the 21st Century
A global challenge in knowledge transfer to meet world demands for food security and sustainability

Conference report and conclusions

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I – Background and goal of the Conference

A major challenge in the 21st Century is that of doubling food production under more restrictive environmental conditions. The agricultural knowledge transfer system, particularly higher education, has a responsibility to adapt and respond to this and other challenges. The obstacles, context, and responsibilities faced by higher education institutions around the world vary widely. The goal of the conference was to convene top-level experts from different areas of the world to foster discussion and prepare recommendations for the future development of curricula in the Agricultural and Life Sciences.

II – Organization of the Conference

The conference was held on 15-17 June 2015, in Zaragoza, Spain, organized by the Mediterranean Agronomic Institute of Zaragoza – International Centre for Advanced Mediterranean Agronomic Studies (IAMZ-CIHEAM), the Centre for Agricultural Research – Hungarian Academy of Sciences (MTA-ATK), the Union for the Mediterranean (UfM), the Association for European Life Science Universities (ICA) and the Global Confederation of Higher Education Associations for Agricultural and Life Sciences (GCHERA), with the sponsorship of the OECD Co-operative Research Programme on Biological Resource Management for Sustainable Agricultural Systems.

III – Participation

Participation: More than 80 participants from 28 Countries (Albania, Algeria, Australia, Belgium, Canada, China, Costa Rica, Egypt, France, Holland, Hungary, India, Ireland, Israel, Japan, Lebanon, Malta, Mexico, Morocco, Poland, Portugal, Romania, Spain, Switzerland, Tunisia, Turkey, United Kingdom, United States of America) attended the conference, representing agricultural higher education institutions and other stakeholders in agricultural curricular reform. Most of participants were academic authorities (rectors, deans and directors) and professors of 35 Agricultural Universities and Faculties of the represented countries. Eleven participants were directives and staff of four international organisations (OECD, CIHEAM, Union for the Mediterranean, Commonwealth of Learning). Eight participants represented seven national and international associations involved in Agricultural Higher Education. Three researchers from public research institutions, 2 administrations high officers, and 2 private firms' executives also attended the conference. Some MSc students of IAMZ-CIHEAM also participated in the conference. The list of participants and their institutional affiliations is available in the last section of this volume.

IV – Conference programme

The conference had thirty conference speakers, chairpersons, and facilitators from seventeen countries. The list of presenters is available in the Conference programme included at the end of this volume. Conference coordinators organized an interactive conference where all presentations had time allocated for questions and answers, and all participants were able to engage in three formal general discussions focused on the analysis and recommendations for future development of curricula in the agricultural and life sciences, as well as informal discussions and networking for sustained collaboration beyond the conference.

1. Conference sessions

Five consecutive sessions, each building on each other, represented the backbone of a programme with 28 presentations and three general discussions. Throughout the sessions, participants analyzed the global challenges for agriculture and higher education in the 21st Century, the drivers for agricultural research and education, and the role of higher education to meet world demands for food security and sustainability. Representatives from around the world (Asia, Oceania, Latin America, North America, Europe, and Northern African countries) reviewed regional challenges and needs, described the educational models adopted in their institutions, and discussed their accomplishments and successes, as well as the barriers for further advancement. Through case studies, presenters analyzed curriculum needs, and offered many examples of innovation, growth, and success in adapting the agricultural curricula to different global, regional, and institutional challenges and contexts. These case studies ranged from non-traditional educational models, open universities and distance education, developing the industry ready graduate, to transformative agricultural education; addressed the needs for technology transfer skills and sustainability competence in curricula, the requirements of the private sector in agricultural higher education, and the role of new biotechnologies in agricultural curricula; and studied the role of quality assurance and program accreditation in supporting development of innovative agricultural curricula. Finally, participants addressed globalization and international alliances, including a model for private enterprise commitment to higher education (Universitas Banco de Santander), joint degrees, and the CIHEAM-IAMZ international cooperative model (Romagosa & Cerezo, 2015). The full conference programme, with presenters' names and affiliations, is included in the last section of this volume. The titles of the five sessions were as follows:

- Opening session.
- Session I: Challenges for agriculture in the XXI Century.
- Session II: Are current agricultural educational models suitable to meet global challenges?
- Session III: Addressing the needs and challenges for innovation in agricultural curricula.
- Session IV: Globalization and international alliances.

2. General discussions

Three general discussions helped connect all presentations and sessions, and gave conference attendees the opportunity to participate in the dialogue, present their ideas, and contribute to the conference.

The following probing questions were used as catalyzers for the discussions, and were meant to integrate the corresponding session presentations and build upon each other.

- How should agricultural higher education adapt to the key challenges of agriculture in the 21st Century?
- What are agricultural higher education programs not doing well to meet these challenges?
- What are some characteristics of programs that are being successful in addressing these challenges?
- To address the challenges of the 21st Century in the bioeconomy[1], graduates of agricultural higher education should be holistic thinkers and effective problem solvers. Are our current curricula fit for this purpose, or what has to change?
- How do we balance between the need for breadth and depth of knowledge within disciplines, and the need to develop students' high level cognition (analysis, evaluation, and synthesis).
- Changing the emphasis from knowledge and understanding to higher order cognitive learning outcomes (analysis, evaluation, and synthesis): Is there a need for change? What are the hurdles in your faculty? What are some success examples?
- What are the indicators that agricultural universities can use to measure progress in curricular development to deliver graduates to address the challenges of the 21st Century?

For each discussion, participants were given several opportunities and tools to provide feedback at the individual and team levels. The probing questions for the discussions were provided to participants individually and in writing at the beginning of each session (in the morning), and displayed in boards at the side walls of the conference room. Attendees were encouraged throughout the day to contribute their individual responses by writing them in cards, and posting them in the conference boards. The posts further stimulated dialogue and provided a good segue to the general discussions at the end of each day.

The general discussion sessions started with small group discussions. This activity was dynamic and engaging from the start because all participants had already had the opportunity to reflect on their own responses to the questions throughout the day. The teams had the opportunity to add their group responses in the conference boards. After this initial exercise, there was a general discussion facilitated by Simon Heath and Maria Navarro.

The participant contributions (individual, team, and general discussions), both in writing and verbally as part of the discussion, were recorded, transcribed, and analyzed for content by the discussion facilitators, after the end of the conference. The resulting themes were integrated into the major highlights from the conference presented in this document.

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[1] The bioeconomy encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy.

V – Major highlights from the presentations and discussions

All attendees are originators and architects of some of the materials presented in this report. A heartfelt thank you is extended to all participants, presenters, conference chairs, coordinators, interpreters, and organizers. Many concepts reported in this document were mentioned many times, by several participants. They turned up in individual presentations, general discussions, small group conversations, or anonymous posts. Thus, it is not possible in this report to give credit individually to all participants for their comments, opinions, or ideas. However, we have tried to cite, when possible, the original conference contributor of distinct concepts, and encourage the reader to refer to their manuscript for further detail.

1. Challenges for Agriculture and Higher Education in Agriculture in the 21st Century

In 2003 Nobel Laureate Richard Smalley developed a list of humanity's top ten problems for the next 50 years: energy, water, food, environment, poverty, terrorism and war, disease, education, democracy, and population (Smalley Institute, 2008). Similar challenges were addressed by conference participants. As presented by Arjen Wals (2015), citing Gibson (2013), these are "wicked" problems that are arduous to define, are not well understood, have ambiguous and conflicting interpretations, and shift with time. Challenges mentioned often during the conference included a growing population; increased demands, pressure, and degradation of resources (soil, biodiversity, energy, water); health and food-related issues and paradoxes (food insecurity, nutritional deficiencies, obesity, food waste); green house gas emissions and global warming (and impact on climate change, variability, and extreme weather events), and other environmental challenges.

Concomitantly, Higher Education and the agriculture sector are facing additional changes and threats to their success. Many presenters argued that students and today's graduates in many institutions are not prepared to address these grand challenges; interest in agriculture studies has declined in the last decades; there is a general erosion of trust in science, inaction, and powerlessness (Wals, 2015); there is a declining role and investment of the public sector in agricultural innovation (Kennelly, 2015); additional societal changes such as globalization, urbanization, technological change, unemployment, migration, conflict, education, etc. greatly affect economic and social sustainability of both consumers and producers; value chains are increasingly complex; and markets, regulations, policies, and governance structures are inappropriate or ineffective, further hindering the efficient use of natural resources (Moreddu, 2015).

2. Response of Higher Education in Agriculture

In the words of John Kennelly (2015), a key factor in maintaining relevance is to evolve to respond to changing circumstances. Conference participants agreed that Higher Education must respond to all these challenges by focusing on adapting practices, processes, and products to improve productivity, efficiency, and sustainability of agriculture to produce more food, healthier food, in less land and with lower impacts on the environment, hence the term "ecological / sustainable intensification" (Minguez & Connor, 2015). Additional foci included universal access to food, as well as adapt to, and mitigate of, climate change.

Thus, according to Minguez and Connor (2015), key features of agricultural production will be increasing application of science and technology, and management by measurement, recording, and analysis of activities and inputs, which will require workers ranging from unskilled labour to highly-qualified academic researchers.

To do that, Higher Education must better understand the challenges it faces, and appropriately identify social, economic, environmental, educational, historical, emotional, technological, and political factors; and clarify and differentiate local, regional, and global context, needs, focus, mission, vision, values, and goals.

3. A new paradigm for the development of innovative curricula

The development of innovative curricula is crucial to respond to these challenges, and paramount to this innovation is a change of lenses and logic: a change of paradigm. This new paradigm should: 1) Strengthen its focus in the co-creation of knowledge and innovation with all stakeholders (Wals, 2015); 2) Follow a cycle of analysis, design, development, implementation, and evaluation (Shinn, Navarro, & Briers, 2015); 4) improve cooperation, efficiency, adaptation, and agility (Meinke, Batt, McKenzie, Bonney, Pratley, & Botwright Acuña, 2015); and 4) lead innovation through both incremental optimization and transitions (change the way we think) (Wals, 2015).

To this end, Higher Education should foster institutional changes and promote a curricular reform that changes what we do and how we do it (learning goals, teaching and learning methods, course structure, program operations, course content, and materials).

4. Institutional changes

Regarding the necessary institutional changes, participants suggested that some possible strategies included the following: 1) Forge public/private relationships, and collaborate with pre-degree institutions, between faculties and institutions, globally; 2) Integrate multiple actors and strengthen collaboration between all stakeholders in education (educators, learners, scientists, communities, government, private sector, organizations, individuals, consumers, producers); 3) connect diversity to teaching and learning processes; 4) Focus on science for society, and treat science/education as a "community" (Wals, 2015); 5) Rebrand, improve, and broaden image to attract more and high quality students: Consider characteristics, background, interests, motivations, and concerns of students (including social awareness and commitment); expand presence (i.e., social media); broaden programs; promote the important role of the bioeconomy and its impact to society (which is important to new generations of students), and promote high employability and quality of education (Meulendijks, 2015); 6) Expand processes to support educational improvement: Focus on new competencies for educators (increase focus on teaching skills, relevance, competency, and flexibility), include teaching quality in promotion considerations, and increase resources to provide professional development and teaching support for educators (i.e., establish university teaching and learning centers); 7) Improve quality assurance and programme accreditation processes (improve indicators, data collection, tools, and processes) (Shinn, Navarro, & Briers, 2015); 8) Introduce place-based institutional sustainability practices (walking the talk: experimenting with, and learning from creating sustainability on location) (Wals, 2015); 9) Participate in non-traditional education models through ICT (i.e., open universities, online courses, open education resources, MOOCs) (Kanwar, 2015); and 10) Strengthen Extension and outreach educational roles.

5. Curricular reform

Many of the discussions and messages from the presentations focused on much needed curricular reforms to innovate and increase impact, relevance to society, rigor, access, efficiency, and quality of higher education in the bioeconomy. To do that, there were suggestions to improve operational and structural aspects of the curriculum (teaching and learning methods, grouping of students, place and time of learning), as well as formal aspects of the curriculum (course content and materials).

A. Operational and structural aspects of the curriculum

To improve operational and structural aspects of the curriculum, suggestions focused on the following: 1) Improve teaching and learning methods by enhancing pedagogical methods (i.e., increase learner-centered focus, experiential and problem-based learning) and engaging students **in** the issues, not by teaching about the issues; 2) Promote authentic and social learning.

Blend formal, informal, and non-formal learning; peer-to-peer, mentorship and apprenticing. Expand internships and blur boundaries between institutional, community-based, and workplace (industry, government, non-profit) learning. Engage students in extra-curricular learning experiences; and 3) Develop mobility programs (from exchange programs to joint degrees between educational institutions) (Van Huylenbroeck & Dewulf, 2015); and integrate information and communication technologies (inverted, blended, online) (Meinke et al., 2015).

B. Formal aspects of the curriculum

A score of suggestions were made regarding improvements to the formal aspects of the curriculum, namely, the course content and materials. A key suggestion that transpired throughout the conference was the **need to diversify and increase focus on the bioeconomy and sustainability.** The bioeconomy encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy. The bioeconomy must be managed with due regard to environmental and social sustainability.

Another key theme, the need to redefine learning outcomes to develop "wiser" students, was largely discussed, countered with even more questions, and received with a mix of enthusiasm and reluctance. To some, their institutions had already addressed such reform, to others, while imperative, there were still many barriers to overcome. Questions surrounding this theme included the degree of change that was needed (how much?), the distribution of responsibilities (who? – instructors, students), the process (how?), and the format (where? – in additional courses, integrated across the curriculum, in internships).

Some of the issues involving the redefinition of the learning outcomes included the following: 1) Increase focus on higher order learning skills (critical thinking, analysis, evaluation, synthesis); 2) Develop graduates who can deal with complexity, are holistic thinkers and effective problem solvers; 3) Extend Bloom's taxonomy by adding a capability extension (motivation, capability, and self-belief) and creativity (Allan & Rowsell, 2015); 4) Integrate, or converge, other disciplines with life sciences. Move toward systems thinking and transdisciplinary learning; 5) Increase reflection, social science focus (impact in society, values, professional responsibility, etc.), and human capacity development (Asanuma, 2015); 6) Support students' development of communication, interpersonal, self-management, teamwork, leadership skills (also framed by many as "soft skills"), as well as innovativeness and entrepreneurship skills (Zaglul, 2015); 7) Provide students with a framework to examine ethical issues, as well as with experience in analyzing these issues (Knauft, 2015); 8) Balance breadth and depth of knowledge, specialization, and outward orientation, to understand whole systems; and 9) Focus on life long learning or job skills? Prepare generalists or specialists? Technicians, engineers, or scientists?

For some, there was also an urgent need to continue research to examine the trends, and improve competencies, frameworks, and pedagogy in the higher education bioeconomy curriculum.

VI – Major outcomes/conclusions in terms of policy relevance

Much of the discussions focused on questions regarding what Higher Education needs to do to position itself to develop innovative, impactful, relevant, rigorous, accessible, efficient, and quality curricula. Key needs addressed included the following: 1) Better identify local, regional, and global challenges in agriculture and higher education that will help determine the curricular goals and changes necessary to meet future demands; 2) Shift from a focus in agriculture to a focus on the bioeconomy; 3) Change higher education's paradigm (a change of landscape requires a change of lenses) and implement institutional changes to support innovation and curricular reform; 4)

Examine competencies for the curriculum. Much emphasis was placed on the balance between breadth and depth of knowledge within disciplines, and on preparing graduates who have better communication skills, are holistic thinkers, and effective problem solvers; and 5) Enhance pedagogical methods toward a more learner-centered education, and promote authentic and social learning. While many participants indicated that their institutions were being successful, others agreed that a score of universities still had to address institutional, environmental, and human resource challenges to be successful in curricular reform, which called for research regarding the challenges/barriers and possible solutions to improving pedagogical methods and determining the changes needed in competencies addressed in the curriculum.

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Session I
Challenges for Agriculture in the XXI Century

Challenges and opportunities for food and agriculture in the 21st Century

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Abstract. The food and agricultural sector will have to respond to growing and changing demand, while facing increasing constraints on natural resource use. It will also have to adapt to climate change, and is expected to contribute to its mitigation. At the same time, the whole supply chain is undergoing significant structural changes and agricultural markets are evolving, notably with the emergence of new players. Innovation will be key for the sector to achieve sustainably the productivity growth needed to meet future demand and ease price tensions on world markets. Agricultural policy reform has an important role to play in facilitating innovation and adjustment, by providing targeted incentives, removing market and trade distortions, providing efficient tools for risk management, and promoting sustainable practices and technologies. But attention should also be paid to other policy areas that contribute to the longer-term competitiveness of the sector, such as the provision of rural infrastructure and services and an efficient regulatory framework. Improving the efficiency and the relevance of agricultural innovation systems is also essential. Developments in agricultural higher education need to be considered in this context.

Keywords. Agricultural markets – Food – Productivity – Sustainability – Agricultural policy.

Défis et opportunités pour l'avenir du secteur agricole et alimentaire

Résumé. *Le secteur agricole et alimentaire devra répondre à une demande croissante et en mutation tout en faisant face à l'augmentation des contraintes sur l'utilisation des ressources naturelles. Il devra également s'adapter au changement climatique et contribuer à sa réduction. Ceci dans un contexte caractérisé par les changements structurels dans l'ensemble de la filière et la transformation des marchés agricoles avec, notamment, l'émergence de nouveaux acteurs. L'innovation sera essentielle pour permettre au secteur d'accroître sa productivité de façon durable et répondre ainsi à la demande future et atténuer les tensions sur les prix des marchés mondiaux. Les politiques agricoles ont un rôle important à jouer pour faciliter l'innovation et l'ajustement par le biais d'incitations ciblées, de l'élimination des mesures qui faussent la production et les échanges, d'e la mise en place d'outils de gestion des risques efficaces, et par des mesures encourageant les pratiques et technologies durables. Il convient cependant de considérer également les autres domaines d'action qui contribuent à la compétitivité du secteur à long terme, tels que les infrastructures et services dans les zones rurales, et la mise en place d'un cadre réglementaire efficace. Il est également essentiel d'améliorer l'efficacité et l'adéquation des systèmes d'innovation agricoles. L'évolution de l'éducation supérieure agricole doit être considérée dans ce contexte.*

Mots-clés. *Marchés agricoles – Alimentation – Productivité – Durabilité – Politiques agricoles.*

I – Global challenges for food and agriculture

The agriculture and agri-food sector is expected to provide healthy, safe and nutritious food for a growing and wealthier world population, feed for increasing farm animal populations, and fibre and fuel for a growing range of industrial uses – all without depleting available land, water and biodiversity resources. At the same time, climate change will affect production conditions, and in particular it is expected to increase uncertainties. Current productivity and sustainability trends raise concerns over the capacity of the sector to meet these global food security and climate change challenges.

Public and private actors will need to work together to improve productivity growth sustainably along the supply chain. This means improving total and partial factor productivity growth and reducing food waste in primary agriculture and at the processing and distribution levels. Natural resources will need to be used more efficiency and sustainability, while negative external effects are minimised. Agriculture will also need to adapt to climate change and is expected, along with other sectors, to contribute to the mitigation of its impacts. Responding to market opportunities will also require the adoption of technologies and practices that are better adapted to changing demands.

II – Productivity and sustainability performance

Since the 1990s, total factor productivity (TFP) growth has been the main driver of agricultural output growth, with land expansion and higher application of inputs per hectare, which used to be the main drivers of output growth, now playing a limited role. TFP growth varies by country and region. Major transition and emerging economies achieved significant TFP growth of over 3% in the 2000s, representing generally a large increase compared to the previous decade, with the exception of India and China (Fig. 1). TFP growth has been more modest and lower than in the previous decade in main OECD agricultural exporters such as Australia, Canada and the United States, as well as in some EU member states like the United Kingdom, and to a lesser extent France. Decreasing TFP growth in high population countries like China and India, and in major exporting countries, has raised concerns over global food security in the future and prompted investigations into the potential causes of these developments, which may include lack of innovation and the impacts of climate change (e.g. Gray *et al*., 2014), It has also led to consideration of government action to foster productivity growth, sustainably (IO, 2012; OECD, 2015a, b, c, d).

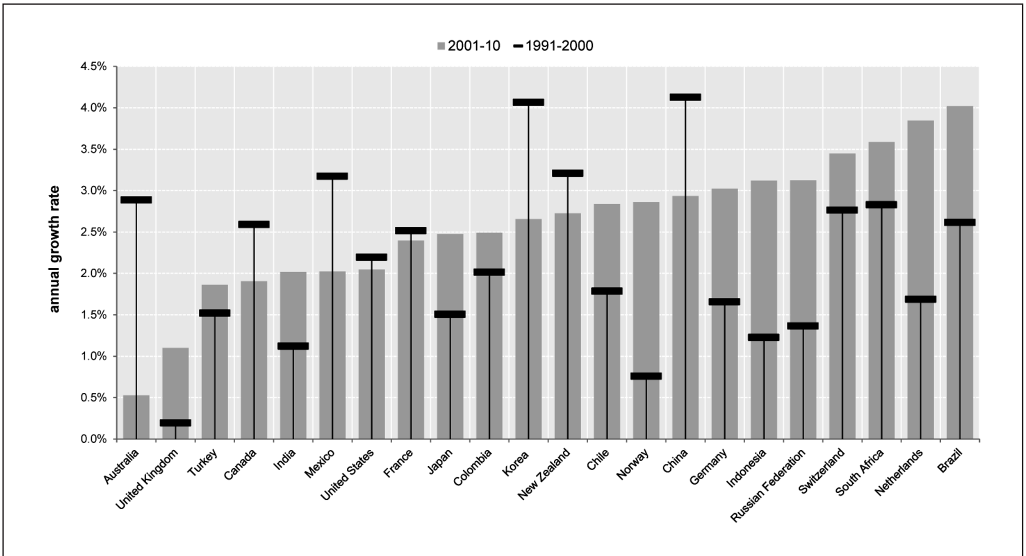

Fig. 1. Total Factor Productivity growth by country.

Source: United States Department of Agriculture, Economic Research Service, Agricultural Productivity Database, 2014. *www.ers.usda.gov/data-products/international-agricultural-productivity/documentation-and-methods.aspx#excel*

Another concern is whether current trends in TFP growth are sustainable in the longer terms. Primary agriculture is a major user of natural resources, in particular in the developing world (Table 1). In many parts of the world, agriculture faces constraints on natural resources. Agricultural land increases at a reduced rate. Two-third of land expansion is in Latin America and Africa, but 70% suffers from soil and terrain constraints (IO, 2012). According to OECD projections, 40% of the world population will live near river basins with severe water stress by 2050 (OECD, 2012). In addition, land use changes are the cause of losses in biodiversity, and agriculture is a major source of pollution from nutrients and greenhouse gas (GHG) emissions (Table 1). Finally, climate change is expected affect natural resource availability and quality, increase weather variability and the occurrence of extreme weather events. This could pose additional sustainability challenges, in particular in countries already under resource stress.

Table 1. Share of agriculture in GDP, natural resource use and emissions

	OECD countries	Non-OECD countries
Gross Domestic Product	2.6%	> 25% in less-developed countries
Land	36%	30-55%
Water	44%	> 70%
GHG emissions	8%	> 17%
Ammonia emissions	91%	> 94%

Source: *OECD, 2013a. OECD Compendium of Agri-environmental Indicators*, OECD Publishing, Paris. *http://dx.doi.org/10.1787/9789264181151-en.* FAO agri-environmental indicators, FAOstat: *http://faostat.fao.org/site/674/default.aspx*

In OECD countries, aggregate trends in agri-environmental indicators show encouraging developments (Fig. 2). In the 2000s, agricultural production has increased using less land, water and inputs, and severe erosion risk is limited to some countries. But more needs to be done as problems of water quality remain, biodiversity losses continue and despite average improvements, problems can remain severe at the local level.

Societal demand is also changing in developed countries. The value of agricultural ecosystem services is increasingly recognised, while concerns for environmental impact of farming are rising.

III – Market developments

Following the price spikes of recent years, food markets are now calmer, with strong harvests and abundant stocks for cereals and oilseeds. Meat and dairy markets follow diverse trends: World markets in 2014 saw record high prices for meat linked to disease outbreaks and herd rebuilding in several countries, but sharp drop in dairy prices resulting from strong production in the European Union and New Zealand, and reduced demand from China and Russia. These developments took place in a context of low oil prices, which make biofuel production not profitable without mandates or support policies, and weak economic growth globally (OECD/FAO, 2015).

According to the most recent OECD-FAO outlook for agricultural markets 2015-2024 (OECD/FAO, 2015), real food prices expected to decline slightly, but remain above levels before 2007-08 food price crisis. As shown in Fig. 3, projected real prices continue a trend of long-term decline. Periods of high and volatile prices may occur, but there is no long term evidence that demand will consistently outstrip supply and reverse this pattern.

The composition of demand is projected to change with consumption of staples reaching saturation in many countries, and demand for protein increasing with income growth. As a result, meat

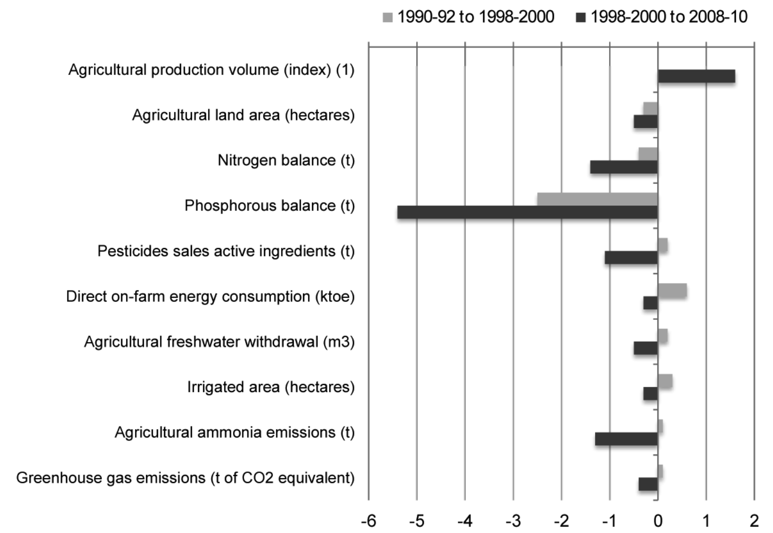

Fig. 2. Key agri-environmental indicators, OECD average, 1990-2010.

Notes: t: tonnes; toe: tonnes oil equivalent; m3: cubic meters; CO2: carbon dioxide.

The OECD total average for the indicators listed here is the average for 34 member countries, except (figure in brackets show the number of OECD countries included in the average calculation): nitrogen and phosphorus balance (31); pesticide sales (29); on-farm energy consumption (32); freshwater withdrawals (24); irrigated area (21); and ammonia emissions (26).

1. For technical reasons, the OECD agricultural production volume annual average growth rate is not calculated for the period 1990-92 to 1998-2000.
2. The annual growth rate for irrigated area between 1990-92 to 1998-2000 was less than 0.1% per annum.

Source: OECD, 2013a. OECD Compendium of Agri-environmental Indicators, OECD Publishing, Paris. *http://dx.doi.org/10.1787/9789264181151-en*

and dairy prices increase relative to crops, and coarse grain and oilseed prices increase relative to food staples, driven by feed demand. Growth in livestock production is expected to outpace crop production in the next decade.

Regional patterns of production and trade are also expected to change. The importance of emerging economies in both production and demand is projected to rise. Imports spread across a large number of countries, while exports are concentrated among a few key suppliers. Asia is expected to account for nearly half of all additional consumption and production in the world. Significant production expansion in Africa is mitigated by population growth. The meat and grain sectors in Latin America are increasingly export oriented as domestic consumption growth slows.

The outlook assumes constant policies and “normal” market conditions but there are risks related to economic growth, energy prices, and agricultural and trade policy changes, as well as long-term structural uncertainties regarding productivity growth rates, natural resource constraints and climate change. In order to prepare for uncertainties, and anticipate unknowns, long-term scenarios can be developed to sketch different futures. This exercise requires collaboration between various stakeholders and experts from different countries. Scenario analysis can serve as a framework for strategic conversations aiming to search for “robust policies” taking uncertainties

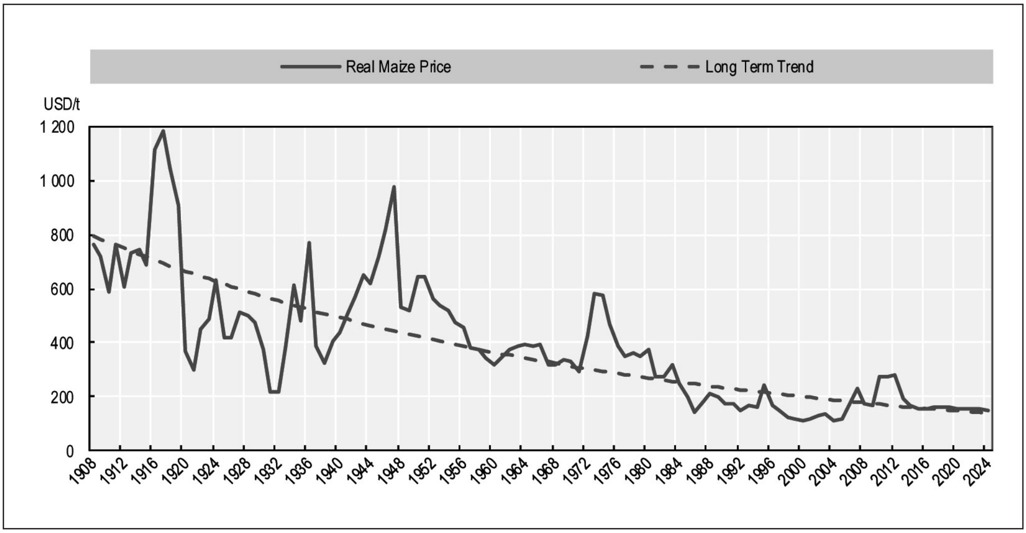

Fig. 3. Long-term price of maize in real terms, 1908-2024.

Note: The US yellow #2 Gulf maize price is used as a benchmark for the coarse grain world market price. This price is recorded back to 1960 in World Bank datasets as monthly data. Monthly prices were converted to annual averages using the maize marketing year September-August. For the years 1908-59 the series is extended using the relative changes in "corn price received" from the USDA quickstats. Nominal prices are deflated using the consumer price as reported by the Federal Bank (*www.minneapolisfed.org/community_education/teacher/calc/hist1800.cfm*).

Source: OECD/FAO, 2015. OECD-FAO Agricultural Outlook 2015, OECD Publishing, Paris.
DOI: *http://dx.doi.org/10.1787/agr_outlook-2015-en*

into account; and guide long-term investment decisions, e.g. in research and development (R&D) and education. The need for foresight exercises is increasingly recognised at national and international level. For example, the OECD recently developed and analysed alternative scenarios for global food and agriculture to help develop robust strategies (OECD, 2015e).

IV – Policy and sector's responses

1. Policy developments

Following a series of reforms and trade agreements since the 1980s, agricultural policies in OECD countries affect agricultural markets to a much lower extent than they used to.

Average support to producers from agricultural policies in OECD countries and emerging economies covers in OECD estimations has been decreasing since the mid-1990s. It represented 17% of gross farm receipts in 2012-14 compared to 21% in 1995-97 (OECD, 2015f). But this hides important differences in support levels between individual countries ranging from taxes to agriculture in Ukraine to support representing over half of farm receipts in Norway, Switzerland, Japan and Korea (Fig. 4). Moreover, while support has decreased in all OECD countries, it has increased significantly in some emerging economies (Indonesia, China and Kazakhstan, and on average support to agricultural producers in OECD countries and emerging economies is converging (Fig. 5).

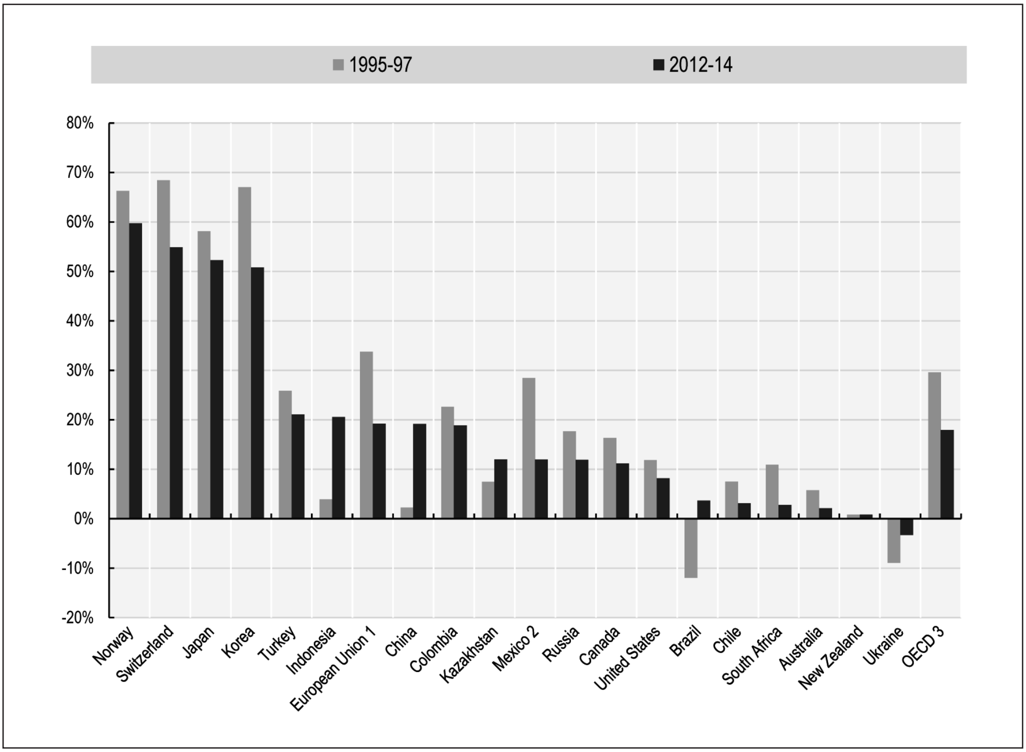

Fig. 4. Producer Support Estimate by country, 1995-97 and 2012-14. Percentage of gross farm receipts.

Notes: Countries are ranked according to 2012-14 levels. EU15 for 1995-97; EU27 for 2012-2013; and EU28 from 2014 when available.

2. For Mexico, 1995-97 is replaced by 1991-93.
3. The OECD total does not include the non-OECD EU Member States. The Czech Republic, Estonia, Hungary, Poland, the Slovak Republic and Slovenia are included in the OECD total for all years and in the EU from 2004.

Source: OECD (2015a), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database). *http://www.oecd.org/tad/agricultural-policies/producerandconsumersupportestimatesdatabase.htm*

In addition to reducing support levels to producers, agricultural policies in OECD countries have also reduced distortions to trade, market and the environment, by delinking the granting of support from current production levels, imposing conditions on production practices, facilitating the adoption of innovations, promoting more sustainable and climate-friendly technologies and practices, and remunerating services. Better targeting towards specific objectives has helped improve the efficiency with which public resources are spent, but in many countries, broad-based income support is still important and domestic prices continue to be maintained above world market levels.

Countries also finance all or part of general services to the sector. These include agricultural R&D, education and advisory services, inspection, rural infrastructure, marketing and promotion actions. These expenditures contribute to improve the long-term competitiveness of the sector, although they do not necessarily benefit individual producers directly. Some countries have focused their efforts in providing an economic environment that enables the sector to invest and innovate in order to become more productive and sustainable.

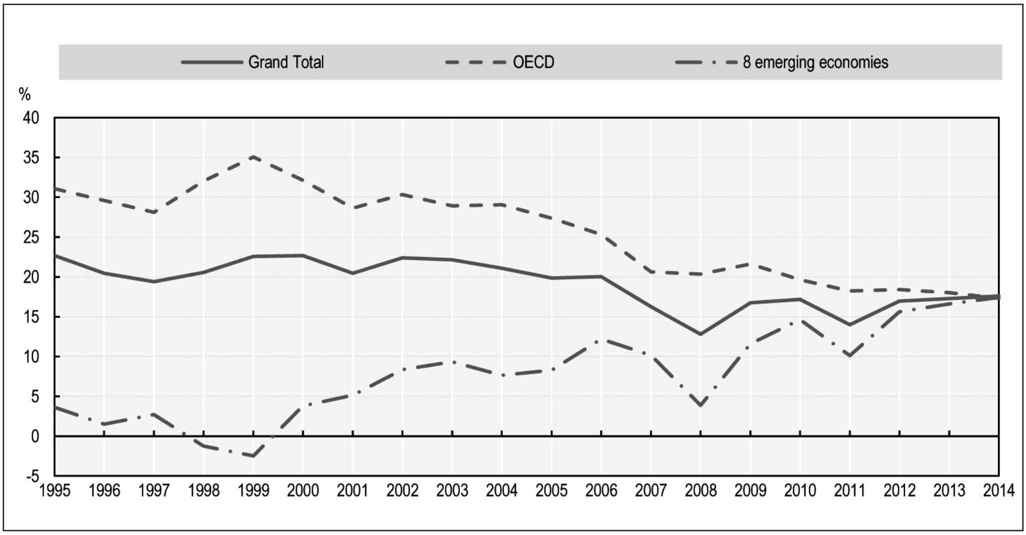

Fig. 5. Evolution of Producer Support Estimate, 1995 to 2014. Percentage of gross farm receipts.

Note: % PSE: Producer Support Estimate in percentage of gross farm receipts.

The OECD total does not include the non-OECD EU Member States. The Czech Republic, Estonia, Hungary, Poland, the Slovak Republic and Slovenia are included in the OECD total for all years and in the EU from 2004. The emerging economies are Brazil, China, Colombia, Indonesia, Kazakhstan, Russia, South Africa and Ukraine.

Source: OECD (2015a), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database). *http://www.oecd.org/tad/agricultural-policies/producerandconsumersupportestimatesdatabase.htm*

2. Sector's response to market and policy changes

Responding to market and policy incentives, actors in the food chain have invested in new technologies and adopted practices to improve economic and environmental performance.

At the farm-level, strategies to adapt are diverse and involve various technological, structural, management and marketing changes, such as investment in equipment for precision agriculture, including Information and Communication Technology (ICT); expansion of farm operations; pluriactivity; diversification of products and marketing strategies; the adoption of risk management strategies at the farm and household levels to deal with uncertainties; changes in legal organisation to isolate business risk; contracting; and greater demand for upgrading skills, leading to the emergence of new actors in the agricultural innovation system (knowledge brokers).

All along the supply chain, companies have also invested to remain competitive. They have invested in R&D, alone or in partnership with public and private research organisations, to develop the innovations needed to meet market demand. These innovations can be technological, but also organisational. Consolidation has taken place, in particular for some segments (e.g. input industries, retail level). Strategies to secure reliable and quality inputs from supplies include vertical coordination, including contracting and technology transfer, which ensures raw material has the required specifications for processing (e.g. high rate of proteins in milk or cereals). Internationalisation of operations, including investments in high growth regions, has been a strategy to increase economies of scale and productivity, diversify risks and enter emerging markets. Market diversification in response to consumer demand, with the development of specific food attributes, but also greening, is a competitive strategy. Efforts have also been made to reduce food waste. These developments are associated with more detailed information to consumers, including the development of various private standards and labels.

V – Conclusions

The food and agricultural sector has a proven capacity to adapt to market and policy changes and take advantage of new opportunities at local, national and global levels. Innovation and structural change are crucial to facilitate adjustment along the supply chain. There is a wide range of areas in which governments could facilitate innovation, structural change and efficient use of natural resources to improve productivity growth, sustainability and resilience along the value chain.

OECD work has traditionally focused on agricultural policy (OECD, 2015f). Main recommendations in this area are to focus public efforts on improving long-term competitiveness and resilience of the sector. This involves moving away from policies that distort markets and restrict competition; reducing impediments to structural adjustment to improve the functioning of input markets, including land and labour; ensuring a clearer, more efficient regulatory environment; facilitating the provision of innovation enhancing services (R&D, advisory services, inspection and control, infrastructure); providing efficient tools for risk management; providing targeted incentives for the adoption of innovative technologies and practices that help increasing productivity, sustainability, while adapting to and mitigating climate change, responding to societal demands such as animal welfare; and facilitating the development of information systems to improve decision-making.

The broader policy environment also affects the food and agricultural sector. Recent OECD work has developed a framework to analyse the role of the government in fostering innovation and productivity growth sustainably (OECD, 2013b, 2015a,b,c,d). It outlines the role of a wide range of incentive areas in: (1) facilitating investment, by ensuring macroeconomic stability, trust in institutions, clear regulations, competition, well-functioning trade and markets to guide industry decisions, access to credit, and taxation; (2) ensuring capacity building, including adequate rural infrastructure and services, flexible labour markets, and an education and skills system responsive to demand; (3) improving agricultural policy efficiency; and (4) ensuring a well-functioning agricultural innovation system, which generates innovations adapted to demand, and thus more widely adopted, and ensures more efficient use of public funds. In this context, education policy is expected to supply the skills needed for the development of the sector.

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

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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.

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Developing sustainability competence and 21st Century capacities through Transformative Agricultural Education

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We live in turbulent times, our world is changing at accelerating speed. Information is everywhere, but wisdom appears in short supply when trying to address key interrelated challenges of our time such as: runaway climate change, the loss of biodiversity, the depletion of natural resources, the on-going homogenization of culture, and rising inequity. Living in such times has implications for education and learning (Wals and Corcoran, 2012).

The introductory quote comes from one of the latest books on education and learning in the context of sustainable development that I was privileged to co-edit with Peter Blaze Corcoran – *Learning for Sustainability in Times of Accelerating Change* (Wals and Corcoran, 2012). There is a widespread consensus that the speed of change, physically, socially and culturally, is accelerating. Continued globalization and digitalization are not only affecting how we think, what we know, who to believe, how we act, they also affect the role of education in society. Higher education, for instance, and the science it produces, is no longer the sole authority of truth, if ever it was. Rather, science oftentimes has been downgrade to just another point of view or an opinion in the public debate of controversial and ambiguous issues such as the causes and impacts of climate change, the role of GMOs in food security, the use of biofuels as a 'sustainable' source of energy, and so on. Scientists can be found on different ends of the ongoing debates, although more might be found at one end than on the other. It is not easy to decide who is right, who is wrong, or who is more right than others, or what the best way to move forward might be. This poses challenges, not just for policy-makers or entrepreneurs, but also for educators. After all, what do we educate for in such a world when things change so fast and knowledge becomes obsolete before you know it? How do we prepare today's graduate for the world of tomorrow? And more specifically, what are the implications for tertiary agricultural education (TAE) around the world?

In this contribution I will highlight an emerging world-wide response that entails a shift from traditional transmissive (based on the transfer of static knowledge from a sending teacher to a receiving learner) to emerging transformative (based on the development of more dynamic competencies in real-world settings based on authentic tasks and issues that require knowledge-in-action) forms of education which we will refer to as 'competence-based' (Mulder, 2012)[1].

[1] See, for a review of the literature on the concept of competence and of the current understanding of professional competence as situated expertise, Mulder (2014). Conceptions of professional competence. Billett, S., Harteis, C. and Gruber, H. (Editors). *International Handbook on Research into Professional and Practice-Based Learning.* Frankfurt, Germany: Springer.

Compared to ten years ago, TAE is more in demand today because of an increased interest in quality-of-life issues, including amongst young people. Issues such as climate change and related worldwide weather-related disasters, the end of peak oil and the search for alternatives, feeding the world and related food-security issues and emerging transitions towards a bio-based economy, circular economies, urban agriculture and sustainable consumption and production, have led to a more prominent place for TAE in the world of higher education. At the same time, agricultural universities started changing their identity by positioning themselves as *life science universities*, while vocational agricultural schools nowadays are often referring to themselves as 'green education institutions' which all aspire to contribute to a better world and improved quality of life.

Clearly the new dynamic in our interlinked world and the new demands and needs that arise from the challenges of creating and supporting developments that are more sustainable than the ones currently employed, requires a number of new competencies. These include; interdisciplinary problem-solving, addressing multiple stakeholder interests, participatory approaches in innovation, interactive methods in conflict resolution, responsive actions regarding community needs, critical media literacy, and social responsibility in entrepreneurship, to name a few, along with those that still connect to specific content areas (e.g. animal science, plant science, environmental science and agro-technology). Relatively new is the notion of sustainability competences (e.g. Wiek *et al.*, 2011; Barth *et al.*, 2007) or sustain "abilities" which add another educational challenge (Table 1).

Table 1. Dimensions of sustainability competence and associated sustain-abilities

Sustainability competence	Examples of sustain-abilities
Dynamics and content of sustainability	• Sustainability literacy • Systems thinking • Adopting an integral view
Critical dimension of sustainability	• Questioning hegemony and routines • Analysing normativity • Disruptiveness, transgression
Change and innovation dimension of sustainability	• Leadership and entrepreneurship • Unlocking creativity, utilizing diversity • Appreciating chaos & complexity • Adaptation, resilience • Empowerment and collective change
Existential and normative dimension of sustainability	• Connecting with people, places and other species • Passion, values and meaning-making • Moral positioning, considering ethics

The competences listed in Table 1 are particularly necessary when seeking to approach the sustainability challenges of our time more holistically, critically, ethically and existentially. If we take food and nutrition security, for example, then we can conclude that most life science schools and universities will have programs addressing aspects of food and nutrition security with the occasional interlinkages, but very few are able to offer an integrative approach that transcends disciplines and sectorial boundaries. This is no surprise of course as our education systems by and large are rooted in a Cartesian view of the world which suggests a reductionist ontology and an empirical analytical epistemology (Peters and Wals, 2013). In a sense one can say, the more educated we become the better we get at thinking the world into pieces and seeing the parts but losing the ability to see relationships, interdependencies and wholes. While the former has brought us much technological progress and improved the quality of life for many, the latter will be needed to deal with the 'wicked' issues that can be considered undesirable 'by-products' of the former (e.g. loss of biodiversity, climate change, micro-plastics in soils, water ways and, indeed, bodies). If we try to look at food and nutrition more holistically, for instance, it would require all the "abilities" listed in Table 1 and probably a few more. If we would just consider the content more holistically it may look like Fig. 1 or Fig. 2 below.

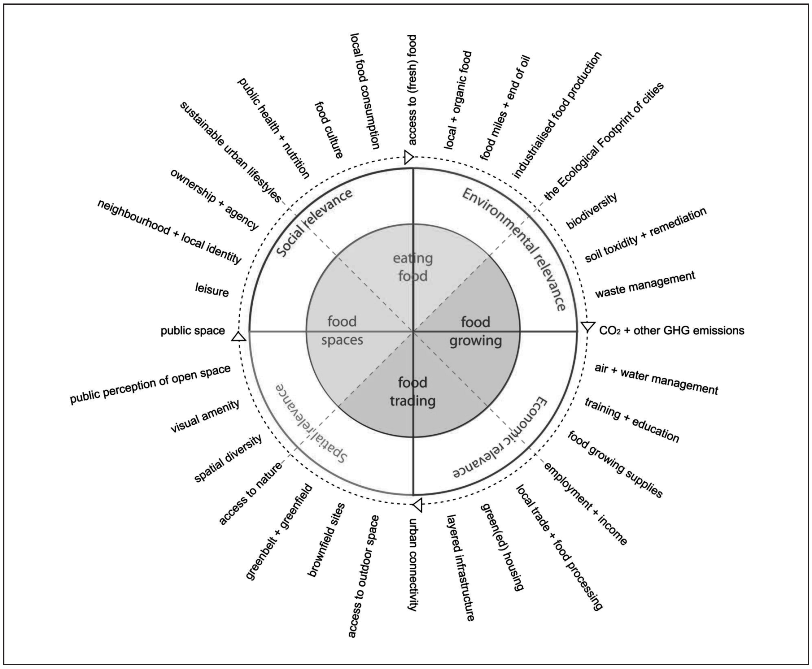

Fig. 1. An effort to consider food more holistically (Viljoen and Wiskerke, 2012).

Figure 2 represent another way of approaching food security in a more holistic way but from another vantage point which is just to illustrate that there is no one way of looking in more integrative ways at complex issues.

Unlike Fig. 1, Fig. 2 also includes the mechanisms that can be used to influence such complex systems: education, research, governance, (chain) management and entrepreneurship.

Figure 2 also illuminates the hybrid playing field of actors engaged in the food and nutrition security and the broader sustainable development domain. Institutions of education and research need to find a position within that playing-field: sometimes playing the role of "innovation broker", sometimes one of provider of certain expertise, sometimes as a source of capacity-building and professional development and sometimes as a bridge between interests and perspectives.

Clearly making agricultural education more responsive to the challenges of the 21st Century is more than just linking up the content of the curriculum to sustainability issues like climate change and food and nutrition security; it also involves developing new competencies such as dealing with complexity, uncertainty and confusion, and devising and implementing meaningful local solutions often with the support of local (vocational) schools and universities. Governments will have to put more effort into stimulating and supporting the 'hybrid teaching environments' or 'learning ecologies' that blur the boundaries between science and society, school and neighbourhood,

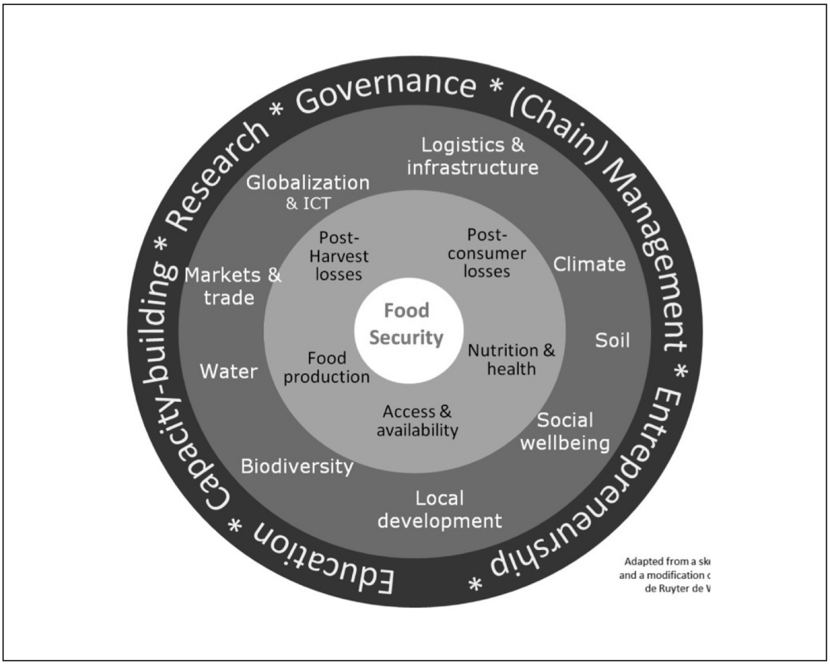

Fig. 2. Food Security: topics, contexts and processes.

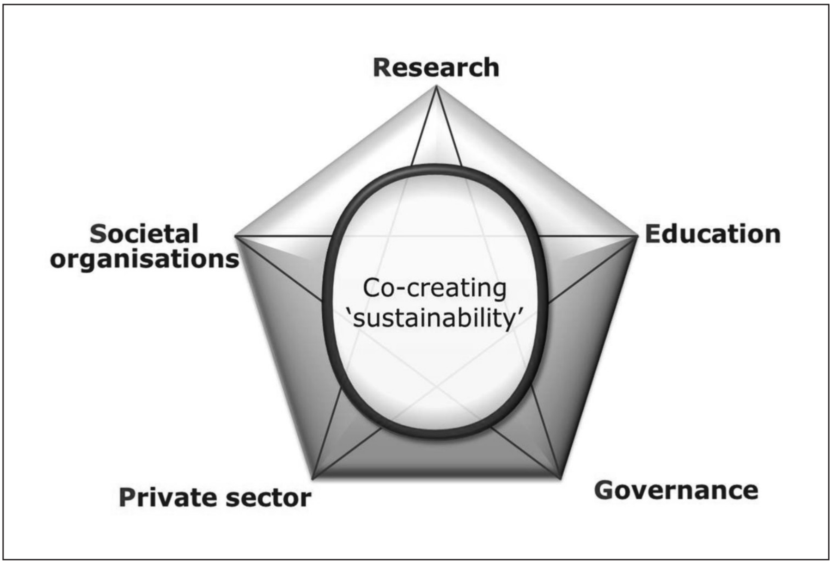

Fig. 3. The 'diamond five' playing field where knowledge about wicked sustainability issues is co-created.

local and global, and shift the emphasis to the wellbeing of mankind and the planet (Fig. 4). The model shown in Fig. 4 shows many elements of what we might call 21st Century education: recognizing the different lenses learners/stakeholder bring to the learning arena, considering the role of (social) media, technology and language in learning, recognizing multiple dimensions of learning from learning for knowing to learning for 'being' and learning to make change, but also acknowledging that education is more that understanding data and acquiring knowledge as it also must be about meaning, understanding and, ultimately wisdom. A learning ecology also suggest that formal, informal, community-based learning, self-learning, apprenticeship learning, ICT-supported learning, all takes place simultaneously in multiple contexts (home, school, workplace, smartphone, etc.). Governments also need to make sure that schools and universities can participate in these arrangements, while schools and universities need to prepare their staff and students for functioning and developing within such arrangements.

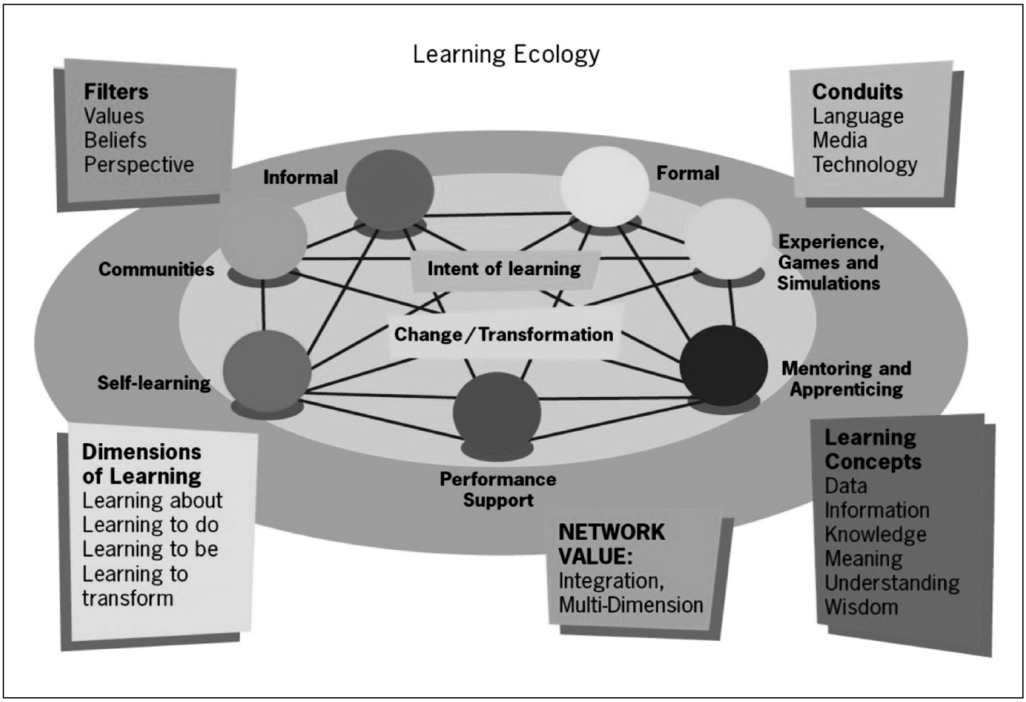

Fig. 4. Creating ecologies of learning (Source: George Siemens, 2005).

Staying closer to 'just' formal education, there will be a need to develop a new didactical orientation which we might dub "sustainability didactics". Sustainability didactics refers to teaching and learning, and the design of learning environments or spaces, that enables learners: to see the world more holistically, to see the local manifestations of global phenomena but also the global manifestations of their own choices and actions, to consider different time perspectives, past-present-future but also to consider short and long term effects, to help them understand systems and systems dynamics, to help them deal with complexity and uncertainty, not with the aim of to reducing them but rather with the aim of making it generative for reflection and continuous learning, and, to engage learners in change and transformation to move beyond awareness and the threat of paralysis by becoming overwhelmed.

Conclusions

The public has various expectations on a multitude of issues in the fields of agri-food production, environment, landscape and the management of natural resources. New competencies are needed for graduates to meet the challenges of a rapidly changing world with diverse societal demands and tightening ecological boundaries. Agricultural educational institutes will need to engage with the new competencies needed and the learning ecologies that are currently being formed around the key issues of our time, many of which are connected to the field of agriculture.

Traditional educational innovation trajectories (based on needs assessment, curriculum design, instructional design, implementation and evaluation) are not sufficient to reorient TAE towards the direction needed within the prevailing global change dynamics. These trajectories take too long because of their inherent time lag of many years. Clear values regarding the content-related issues together with an appropriate educational philosophy are imperative. As Wals and Bawden already wrote in 2000 such a philosophy will require an educational orientation from:

- Consumptive learning to discovery learning in open-source environments
- Teacher-centred to learner-centred arrangements
- Individual learning to collaborative learning
- Theory dominated learning to praxis-oriented learning
- Sheer knowledge accumulation to problematic issue orientation
- Content-oriented learning to self-regulative learning
- Institutional staff-based learning to learning with and from outsiders
- Low level cognitive learning to higher level cognitive learning

In the future, universities and vocational learning institutions, whether they are framed as "agricultural", "green" or "life-science" who are able to rethink their educational philosophy and their relation with society will be given greater recognition as leaders in society where cutting edge new knowledge is generated. They will constantly question and reform deeply entrenched unsustainable routines, structures and practices and engage in collaborative endeavour in continuously seeking to preserve people and planet, where the economy is a means, not an end. Finally, the educational institutions themselves and the community of which they are part will have to mimic the kind of sustainable practices they seek to promote in its research and education in the way it runs its own business. The University of the Future lives and learns by example. Failing to do so will widen the gap between rhetoric and reality and further undermine the credibility of education and research.

Aknowledgements

I wish to acknowledge Martin Mulder & Natalia Eernstman for their contributions. More up to date ideas and resources can be found at: www.transformativelearning.nl

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Ethics in the agricultural curriculum

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Abstract. Researchers, producers, and educators in agricultural sciences face many ethical issues related to a number of issues, including food production, food safety, environmental quality, food security, and international trade. Programs of study in agricultural higher education can provide students with a framework to examine ethical issues, as well as with experience in analyzing these issues. Some colleges of agriculture require all undergraduates to complete a course in agricultural ethics. Frequently such a course is team-taught by an ethicist and one or more agricultural scientists. It provides students with a background in ethical theories and exposes them to the processes used to make ethical decisions. Disadvantages of this approach include difficulty in adding a course to already crowded curricula and the need to examine broader ethical issues rather than discipline-specific ones. Another model incorporates ethics directly into courses in a range of agricultural subjects. While less time is spent on ethical theories or ethical decision making, students can still be exposed to these concepts either by a guest speaker or by the disciplinary faculty member teaching the course. With this model, students are exposed to ethical issues of greater interest to them. Research has also shown that incorporation of ethical topics can enhance learning scientific content.

Keywords. Teaching agricultural ethics – Food security – Food safety – Environmental quality – Ethical decision-making.

L'éthique dans les cursus agricoles

Résumé. *Les chercheurs, producteurs, et enseignants du domaine des sciences agricoles sont confrontés à de nombreuses questions d'éthique liées à plusieurs enjeux, notamment la production alimentaire, la sécurité sanitaire des aliments, la qualité environnementale, la sécurité alimentaire quantitative, et le commerce international. Les programmes d'étude de l'enseignement supérieur agricole peuvent apporter aux étudiants un cadre pour examiner les questions éthiques ainsi qu'une certaine expérience concernant l'analyse de celles-ci. Dans certains collèges d'agriculture tous les étudiants de premier cycle doivent impérativement suivre un cours en éthique de l'agriculture. Souvent ces cours sont délivrés en tandem par un expert en éthique et un ou plusieurs scientifiques en agriculture. Ceci confère aux étudiants un bagage en théories éthiques et les familiarise avec les processus employés pour prendre des décisions en matière d'éthique. Parmi les inconvénients de cette approche figurent la difficulté d'ajouter un cours à un programme d'études déjà très chargé, et la nécessité d'examiner des questions éthiques bien plus vastes plutôt que celles liées spécifiquement à cette discipline. Un autre modèle incorpore l'éthique directement dans les cours pour tout un ensemble de thématiques agricoles. Bien que l'on consacre moins de temps aux théories éthiques ou à la prise de décision éthique, les étudiants peuvent néanmoins être familiarisés avec ces concepts soit par un conférencier invité ou par le membre de la faculté concernée qui délivre le cours. Avec ce modèle, les étudiants sont sensibilisés aux questions éthiques qui leur sont d'un plus grand intérêt. La recherche a également démontré que l'incorporation des sujets éthiques peut renforcer l'apprentissage de contenus scientifiques.*

Mots-clés. *Enseignement de l'éthique de l'agriculture – Sécurité alimentaire quantitative – Sécurité sanitaire des aliments – Qualité environnementale – Prise de décision éthique.*

I – Introduction

Food production is one of the basic requirements for human life. Researchers, producers, and educators often feel that being involved in agriculture puts their activities on high moral ground. After all, they grow food, and without it, humanity would fail to exist. In that light, whatever can be done to grow more food of higher quality for lower cost has been perceived to be of value to society. For these reasons, there has historically been relatively little examination of ethical issues surrounding food production, either in agricultural research or in agricultural higher education (Chrispeels and Mandoli, 2003).

However, this scenario is changing. The global society is asking many questions about the nature of our food system. Included among the topics of importance to consumers (and therefore of importance to producers, researchers, and educators) are the structure of farms, ethics of animal production, food safety, environmental impacts of agricultural production, international trade, food security, the use of biotechnology in agriculture, and trust in science (Burkhardt, Comstock, Hartel, and Thompson, 2005; Grimm, 2006).

Those of us who are agricultural researchers and educators have a responsibility to join in the conversations about these topics. Our perspectives as scientists conducting research relevant to these topics are critical for informed, intelligent discussions and policy decisions. We also must raise these issues where appropriate in courses we teach. When our students graduate and contribute their agricultural technical expertise to society, they must also be able to articulate and defend the ethical implications of the work they do. Yet too often, we do not provide students with the exposure or the tools for intelligent discussions on ethical issues in agriculture.

II – Ethical issues in agriculture

The range of topics that concern the general public touches on virtually all agricultural disciplines. For example, questions regarding farm structure include the following: Will (and should) the family farm survive? What role do governmental programs play in helping or hurting the chances of family farm survival? What influences production and marketing decisions at the farm level? What is the relationship between input suppliers, farmers, and marketing firms? Will global agriculture become industrialized and controlled by large agribusiness corporations? What type of agriculture is wanted in the world?

Ethics issues in animal production can be particularly divisive. What role should animal products play in a human diet? How should animals be raised for meat and dairy products? How should they be fed? How should animal diseases be managed? How should animals be used for research?

In addition to the science of food safety, issues of risk analysis and recommendations have ethical components. How should recommendations on risk, food safety policies and procedures be developed and communicated? What role does the ‘right to food’ play in food safety?

Environmental impacts of food production affect all of society. What are the most effective, efficient, and safest methods for managing soil fertility, weeds, insects, and diseases affecting plants? What are the most effective, efficient, and safest methods for raising animals? What are the environmental effects of the globalization of food production?

What are the ethical standards that should govern international food trade? How do fair trade practices impact the ability to provide high quality food, to provide food that protects the health of consumers, and enables fair access for all people to high quality food?

How can we contribute to the concept that all people at all times have access to sufficient, nutritious, and safe food needed to lead healthy lives? What difference does it make that a growing world population is becoming more affluent and as a consequence dietary preferences are resulting on too much food? How do we address the obesity issue? What factors affect a country's or culture's ability to provide stable and safe food for its citizens?

Another highly polarizing issue in agricultural sciences is the use of biotechnology. What aspects of biotechnology are appropriate to use in research and which are not? Should this technology be used to increase efficiency of traditional breeding efforts in plants and animals? Should it be used directly to create new strains of animals and cultivars of plants?

Many of these questions and issues relate directly to topics and concepts we teach in agricultural higher education. Thoughtful discussion of these topics when they arise in agricultural courses can provide students with both exposure and some understanding of ways to discuss emotional topics that are important to their careers. This is critical given the change in dynamics of society's trust of scientists and the scientific information that is brought to bear on these ethical issues.

While many polls around the world have indicated that the general public has a high level of trust in scientists and their discoveries, increasingly society is becoming more skeptical of what we discover and report. Perceptions of global warming, evolution, overpopulation, pesticide use, vaccine use and other scientific topics all show distinct differences between the general public in the United States and members of the American Association for the Advancement of Science (AAAS) in a poll conducted recently (Pew Research Center, 2015). Also, in just the five years since the previous Pew Research Center study in 2009, the number of AAAS members who feel that "today is a good time for science" has plummeted from 76 percent to 52 percent (Pew Research Center, 2015). As an example of continued reduction in public trust of scientists, a recent, highly publicized, report from the United States by Young and Penzenstadler (2015) identified a range of biosafety incidents involving highly infectious pathogens in federal and state laboratories and has fueled concerns over the quality of scientific research.

III – Teaching agricultural ethics

Given that students in agricultural higher education are facing these issues now as citizens and students and should be in the forefront of these dialogs when they graduate because of their interest, expertise, and vocation, what role should the teaching of ethics play in our classrooms? This is a significant dilemma. First we want to provide students in our courses with the knowledge and skills they need to be successful agricultural professionals. Yet there is far too much material to cover in a typical course. In the United States higher education system, a standard science course without a laboratory meets for 50 minutes 3 times a week for 16 weeks, a total of 40 hours. I started my faculty career as a genetics instructor in 1977. I was told at the time that global genetic knowledge doubled every three years. If this was true and continued to be so from that time until today, there is now thousands of times more genetic knowledge than there was in 1977. But the introductory genetics course in 2015 still meets for a total of 40 hours. If appropriate content was taught and mastered by students receiving good grades in 1977, how can we say that sufficient content is mastered 38 years later?

In recent years, this explosion in information has also been accompanied by a dramatic shift in the ability of people to access this information. Individuals can obtain legitimate scientific information online (for example, with Google Scholar) and massive online open courses (MOOCs) promise opportunities for anyone to take higher education courses for free. Many people worldwide have suggested that universities essentially lack relevance, and with the technological democratization of knowledge, motivated individuals can obtain necessary skills and information to succeed in anything at any level – without universities (University World News, 2014).

However, much of this criticism rests on the supposition that higher education focuses on what kind of job students receive upon graduation. In reality high quality education focuses on what kind of people students want to be. The maturation of young people through interactions with other students, between faculty and students, and learning through hands-on doing of agricultural skills, all suggest that we can and should continue to teach in university settings. Adding a component of ethical awareness to that higher education agricultural setting can prepare our students to be global citizens involved in agriculture who are ethical and are ‘doing the right thing.

Yet we still must address the explosion in content and skill requirements. We teach an every-changing set of core knowledge and discipline-related skills that we perceive as important to our students. But especially today, it is not possible to teach all the content and skills needed by our students, and they will need new content and skills as they progress in their careers. It is therefore critical that we help our students learn how to learn, learn where to obtain valid information for new situations, learn how to think critically and how to solve problems. And a portion of that learning, thinking, and solving needs to include not just raising animals and growing plants, but helping them develop an understanding and a process to examine the ethical issues in the context of both science and their own moral codes.

How can we do this in undergraduate programs in agricultural disciplines? It is a significant challenge. Virtually every undergraduate curriculum I am familiar with has to wrestle with incorporation of course demands for competency in the discipline. In many institutions of higher education that award agricultural degrees there are also requirements for breadth of learning in the liberal arts. If we agree that helping students to navigate the important ethical issues in agriculture is crucial to our role in preparing them for a career in agriculture, how do we do this?

1. Types of agricultural ethics courses

There are a number of considerations to address in teaching ethics in agriculture. From a structural standpoint, how do we incorporate agricultural ethics into a curriculum? The continuum of options starts with the creation and requirement of a single course in agricultural ethics at the university or college level and ends with deciding to do nothing. Between these options there can be a number of alternatives, including offering a broad-based elective course in ethics, requiring a discipline-specific ethics courses for all students, or incorporating ethics into required disciplinary courses, either in a range of upper-level courses or a single capstone course.

A. Advantages of a core course

From my experience, few faculty or students in agriculture have a background in philosophy or ethics. A core course can expose students to ethical theories and the process of ethical decision making. A single course could be team taught by an ethicist and one or more agriculture faculty members. The ethicist could explain ethical theories and the basis for ethical decision making. The agriculture faculty could bring scientific perspectives and between them create opportunities for students to apply ethics to important agricultural issues.

When students in the agricultural sciences are exposed to ethical issues, one of the most disturbing facets to them is that the science they are learning seems objective, while ethics seems highly subjective. One way of addressing this issue is to expose them to ethics frameworks, such as that developed after WWII from the Nuremberg trials and the resulting Nuremberg Code (United States Department of Health and Human Services, 2015a) or the Belmont Report (United States Department of Health and Human Services, 2015b).

They include:

“1. Respect for Persons. Respect for persons incorporates at least two ethical convictions: first, that individuals should be treated as autonomous agents, and second, that persons with diminished autonomy are entitled to protection.

2. Beneficence. Persons are treated in an ethical manner not only by respecting their decisions and protecting them from harm, but also by making efforts to secure their well-being. Two general rules have been formulated as complementary expressions of beneficent actions in this sense: (1) do not harm and (2) maximize possible benefits and minimize possible harms.

3. Justice. The formulations of just are (1) to each person an equal share, (2) to each person according to individual need, (3) to each person according to individual effort, (4) to each person according to societal contribution, and (5) to each person according to merit” (United States Department of Health and Human Services, 2015b).

These principles can be used by students to frame their ethical perspectives, regardless of the topic. They can be, in a sense, the “scientific method” for ethical decision making. By explaining these ideas to students, their concern about the subjectivity of ethics is often reduced. This familiarity with moral philosophy/ethical concepts can also create a neutral ground where dialogs on philosophy, moral choices, and science can combine to create somewhat less of an ‘us *vs* them’ or a highly emotional approach to these complex topics.

In a single course, students from all agricultural disciplines at an institution would be required to take an ethics course. It would mix many disciplines that could give students an understanding of ethical issues in the broad context of agriculture. Plant pathology students would learn about ethical issues in animal husbandry. One or more agricultural scientists as co-instructors would bring their experience, research, and teaching perspectives to ground the discussions in topics that would be relevant to the students.

B. Disadvantages of a core course

A new course in agricultural ethics would need to be supported by affected faculty and approved by the appropriate authorities at an institution. As Booth and Garrett (2004) have indicated, many faculty are, at best, ambivalent about such a course because it either would need to replace a required course in their discipline or reduce students flexibility to take an elective class. The involved ethics and agricultural science faculty would need to have the desire and skills necessary to team-teach such an interdisciplinary course, and funds would need to be provided for faculty salaries. Often, a required course such as this is perceived by students as something forced on them with little relevance to their training (Jagger and Furlong, 2014).

C. Infusing ethics into disciplinary courses

Jagger and Furlong (2014) make the argument that we shouldn’t just tell students there are ethical issues, but help them develop a way of reasoning through the challenges and come to some resolution. Rather than a single required course in agricultural ethics, another method of teaching ethics is to incorporate ethics into disciplinary courses in agriculture. This can take the form of a single, separate module in a course, or weaving the insertion of one or more ethical issues at several points in a course.

This vertical integration approach has advantages. It eliminates the need for additional courses in a curriculum and additional faculty hiring. It creates a context for an ethical discussion that is disciplinary specific and thus one that students have both interest and some developing expertise.

Schultz (2014) has identified some common concerns raised about this decentralized approach. Some individuals are concerned that agricultural science educators are not trained as philosophers and are therefore not qualified to teach philosophical issues in their disciplinary courses. A related issue is that, because we teach "pure" science where there is an objective right and wrong answer, adding moral issues with no universal agreement on wrong and right is outside our purview and should be left out of our teaching.

Others are of the opinion that it is inappropriate for higher education institutions (especially public ones) to raise ethical issues and thus influence the moral development or values of students. The last objection is that discussion of ethical issues would take valuable time away from a science course to address non-science issues.

Each of these concerns can be addressed. For example, while scientists often have no training in ethics, they can bring in guest speakers with this expertise, audit courses themselves in ethics, or participate in various short courses and workshops. Naqvi (2009) contends that one does not need to be a trained bioethicist to incorporate important topics of bioethics in a curriculum, and that foundations of ethical issues are common to all humanity.

Schulz (2014) argues that scientists specialize in the application of knowledge for the betterment of humanity, and as such put science in the context of the world. This context places us squarely in the middle of both science and ethics, which we have an obligation to share with our students.

Thinking it is inappropriate to include ethics in agricultural curricula because we may influence our students' moral development assumes that scientists teach their discipline in a value-free manner. Numerous researchers, including Posner (2004) and Umbach and Wawrzynski (2005) have shown that teachers influence students through the myriad ways they interact. The issue is that excellent teachers don't teach students what to think, but how to think. There is a significant difference.

A counter to the fourth argument has already been raised in this manuscript. We in agricultural higher education cannot truly prepare our students for careers in agriculture without exposing students to ethical issues and preparing them to respond in an informed and thoughtful manner. Interesting research by McGowan (2013) has shown that students retain scientific knowledge better when they are taught in the context of ethical dilemmas, because students are more personally engaged in the topic.

2. Teaching techniques for agricultural ethics

While incorporating ethics can be a challenge for agricultural educators, it also allows an opportunity to use a wide range of teaching techniques. For example, Quinn, Harding, and Matkin (2011) randomly assign students in teams. Readings and quizzes are assigned before ethical topics are discussed in class. The quizzes are graded individually, then students are asked to give a group response to the questions, with the subsequent group score incorporated into each student's grade. Each group is assigned an ethical topic and must research the issue before creating a poster, dialog, and presentation.

Diebel (2008) is a scientist who teaches a course with guest philosophers. Students must do readings, understand case analyses, and then are assigned ethical issues. They must describe the moral principle used to come to their conclusion. There are in-class assignments where groups of students briefly analyze a situation with a given moral principle, then must respond to an evaluation of their conclusions with a different moral principle.

Pearce (2009) has an extensive course with group activities. Facilitators float among groups to assist when in-class activities are conducted. There is a mix of individual written assignments and group activities. For each issue, the fact, the value statement, and then the conclusion are required. There is a significant feedback process in the class that includes steps identifying students' initial reaction to the topic, benefits or disadvantages to interested parties, adding relevant facts, examining the topic from the diametric opposite perspectives, then only at the last part of the assignment, arguing their point.

Jagger and Furlong (2014) describe an approach where disciplinary faculty develop a single ethical issue from their own area of expertise and use readings, group work, case studies, and in-class presentations to foster a deeper, more responsible thinking from students than would otherwise be available.

Loike, Rush, Schweber, and Fischbach (2013) teach a required science ethics course, although their techniques can be beneficial in centralized or decentralized agricultural ethics teaching. They require background reading in both science and ethics journals, particularly emphasizing presentations with several opposing viewpoints. Online discussions of posted questions facilitate covering the topic outside of the classroom. The authors found that when the course devoted more time in the classroom to discussion, debate, and role-playing, students appeared to better grasp the presented ethical issues.

IV – Conclusion

Exposing students in agricultural higher education to ethical decision-making and its application to important ethical issues will continue to be an important part of their preparation for an agricultural career. There is a range of options for incorporating ethics into agricultural curriculum, from an ethics course required of all students in a college to use of a specific case study in capstone disciplinary courses. The flexibility of the structure and methods used to teach ethics provides faculty with many useful options to address this important issue.

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Agricultural Higher Education in the 21st Century. Student view: attractiveness and employability

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Abstract. By the year 2050, an enormous increase in food production is needed to sustain global food security. Because the students of today will be the professionals of 2050, it is extremely important that a sufficient number of students is being educated to realize this increasing food demand. However, the problem is that currently too few students are interested in studying the field of agriculture and related sciences. In this paper, the reasons for this low interest are analysed on the basis of answers given in interviews with agriculture related students from all over the world. It seems that the current image of agriculture in developed regions is one of the obstacles in attracting enough students. Improving society's awareness on the role of agriculture in our daily lives can greatly improve the image of the sector in general and therefore the amount of students choosing this particular field of study. Other possible reasons for low interest in the study like the quality of the study, the extra-curricular opportunities and the career perspective after graduation were analysed as well. They were found to be positive compared to other careers. Something that most students that are at the point of choosing their study have no idea of. Improving the marketing of these positive aspects is a way to improve the number of students applying for a study in the field of agriculture or any related science.

Keywords. Attractiveness – Employability – Agricultural Sciences – Student view.

L'enseignement supérieur agricole au XXI^e^ siècle. Le point de vue des étudiants : attractivité et employabilité

Résumé. *À l'horizon 2050, une augmentation énorme de la production d'aliments sera nécessaire pour assurer la sécurité alimentaire mondiale. Vu que les étudiants d'aujourd'hui seront les professionnels de demain, il est d'une extrême importance d'en former un nombre suffisant dans ce domaine afin de palier au mieux à la demande alimentaire mondiale. Le problème est qu'actuellement le nombre d'étudiants intéressés par des études dans le domaine agricole et des sciences connexes est trop petit. Dans cet article les raisons à ce manque d'intérêt sont analysées en se basant sur des réponses données lors d'entretiens avec des étudiants des filières agricoles de par le monde. Il semble que l'image qu'a actuellement agriculture dans les régions développées du globe soit un réel frein à l'adoption de ces études. Promouvoir l'agriculture au sens large et sensibiliser la société au rôle qu'a l'agriculture dans nos vies quotidiennes pourrait améliorer fortement l'image du secteur et permettrait par conséquent d'augmenter le nombre d'étudiants choisissant des études dans ce domaine. D'autres raisons probables à ce manque d'intérêt ont également été analysées, telles que la qualité de l'enseignement, les opportunités extra-universitaires et les perspectives de carrière une fois les études achevées. Celles-ci se sont avérées bonnes comparées à celles d'autres filières, mais c'est quelque chose qui n'est pas perçu par la plupart des étudiants sur le point de choisir leurs études. Améliorer le marketing de ces aspects positifs serait une manière d'augmenter le nombre d'étudiants posant leur candidature pour une formation dans le domaine de l'agriculture ou de toute autre science connexe.*

Mots-clés. *Attractivité – Employabilité – Sciences de l'agriculture – Point de vue des étudiants.*

I – Introduction

Mainly due to exponential population growth, world agricultural production has to increase by at least 60 per cent within the next 35 years (Alexandratos and Bruinsma, 2012). At the same time almost all arable land has already been taken into cultivation and vast expansion of agricultural area is no option. This means that one of the main ways to meet this increasing food demand must come from an increased yield per hectare. To establish this increase in productivity, it is essential that knowledge of agronomy is applied into the fields. Nowadays a lot of agricultural research is being done to find the best techniques to meet this increasing demand. However, the number of students interested in studying agriculture or any related science is lagging behind, which causes a hampering of the innovation and application of agricultural knowledge.

Today's students will be the professionals of 2050. They will be the agronomists, the scientists, the farmers, the politicians or anyone having a function in the agro-food chain who all have to deal with the skyrocketing food demand of that time. They will be the ones who will actually have to realize this rise in food supply; something they cannot accomplish if they are too few in number. Not educating enough agricultural students today will therefore have its severe consequences in the future.

To find out the reasons behind the (lack of) popularity of agricultural sciences, 19 under graduated university students of the field of agriculture or related sciences have been interviewed. These students are members of IAAS and come from 15 different countries, both from the developed and developing world (Table 1). Questions related to the popularity of their field of study, in particular about the image, the curricular and extra-curricular content (among other topics) were discussed with them electronically, in real life or on paper, after that these students had discussed the questions with their fellow students at their local university. For the questions and answers, see annex.

Table 1. Interviewed students

Country	University	Degree	No. students
Benin	University of Abomey-Calavi	Agricultural Engineering	1
Canada	Université Laval	Bachelor agronomy, business profile	1
Chile	Universidad Mayor - Santiago	Bachelor Agronomy	1
Croatia	University of Zagreb	Agronomy	2
Germany	Universität Bonn	Agronomy	1
Indonesia	Bogor Agricultural University	Agronomy	1
Italy	Universitá del Molise	Agronomy	1
Mexico	Tecnológico de Monterey, campus Querétaro	Agronomy	1
Spain	Universidad Politécnica de Madrid	Agronomy – Agricultural Engineering	4
Belgium	KU Leuven	Master Agro- & Ecosystems engineering	1
Uganda	Busitema University	Agronomy	1
Ukraine	National University of Life and Environmental Sciences of Ukraine	Animal Husbandry	1
Zimbabwe	Africa University	Agronomy	1
Nepal	Tribhuvan University	M.Sc in Agri-Economics and Agri-business Management	1
USA	Iowa State University	Global Resource Systems	1

II – Choice of study

The reason why too few students are interested in studying agriculture can be analysed on basis of the factors that determine the choice of study of a high school student. Several aspects play a role in this decision. First of all, a study needs to be interesting to the student. Next to that, the possibility of future jobs related to the study must provide a certain level of comfort, social status and job security. Also the attractiveness and location of the university can play a role in the decision making. Finally, an aspect that is increasingly important to the millennial generation, is the fact that we want to make a constructive contribution to this world. Those of my generation who were raised in the developed world have, most likely, only known abundance and wealth. This abundance and wealth has its effects on the values we seek in life and consequently also the values we seek in a job. For our parent's generation, wealth was of greater importance, being a factor that was less abundant in the time that they grew up. Since this wealth has continuously been present in most of our life's, most of us, (64% according to a study done by The Intelligence Group) (Hershatter and Epstein, 2010), find it important to actively participate in making this world a better place.

On the basis of these factors that determine the choice of study of a high school student, the question can be asked: at what point does agriculture lose from the popular studies? Why do students currently prefer other studies above those related to agriculture?

III – Image of agriculture perceived by students

1. Current image

The first step in attracting more students in the field of agriculture is increasing the general interest of students in the sector. At this point, the vast majority of high school students never even considers to study agricultural or any related science. As long as students remain ignorant to the sector they consequently will not inform themselves about the content and quality of the study, nor will they learn about the job opportunities this field can offer them. It is important to increase this interest in the agricultural sector in general in order that improvements in the quality of the study itself or its career possibilities can have a higher positive effect on the number of students choosing to study agriculture.

Currently the image of the field of agriculture in most of the developed countries is, to formulate it bluntly, "uncool". The majority of interviewed students coming from the developed region mentioned that students from other degrees in general enjoy a higher social status than they do. Several of them addressed the fact that they have to defend their choice of study to friends and family that are unfamiliar to the field and who are wondering why they didn't choose to study a "higher" degree, or a "real university study". This shows a reflection of the status that comes along with- and the general perception of agriculture and related sciences. Others however, mentioned that for them this was not exactly the case and that they did have a good image among other students. This was, for example, the case in Latin America (Chile and Mexico), where a relatively high percentage of the students studying agriculture at the universities of the interviewed students are coming from a big ranch or latifundium, and therefore enjoy a higher social status. This was also the case for those students who study agricultural- / bio-science engineering. The "engineering" part of the study delivered them a certain esteem in society, they said.

In developing countries, the case is different. In many of them a certain part of the population is facing food security problems themselves. This makes that the awareness of the role of an agronomist in their daily life is much bigger. In these countries, the students have indicated that the agricultural students enjoy a higher social status and the number of students showing interest in agricultural sciences is substantially higher.

2. What forms this image

Why is it that the image of agriculture in developed regions is so unfavourable compared to the image of other university degree sectors?

Firstly, this can be explained by the fact that agriculture is bound to a rural environment. Most of the youth is attracted to live in big cities that can offer a wide range of activities and opportunities for them. It is popular to be a YUP: Young Urban Professional. Unfortunately, the term YRP's (Young Rural Professionals) does not exist.

Secondly, the look associated with agriculture is in general less attractive than those of, for example, a businessman, lawyer or a doctor. Off course, this depends strongly on one's personal opinion but in general a dirty and smelly overall isn't found as appealing as a fancy suit, court dress or even something as a lab coat.

To conclude: one of the factors that influences the image of agriculture relates to the fact that the relationship between science and agriculture is not as strong as in other careers. From its very beginning onwards for many years agriculture was a practice without any scientific input. Off course, there have been improvements of agricultural practices but this was more due to an empirical effect comparable to Darwin's survival of the fittest: the agricultural practice that worked best was repeated the subsequent year. The low input of science into agricultural practise even continues nowadays. If you have no education and not the opportunity to find another job, the most obvious thing you would do to survive is to become a subsistent farmer. The cases for studies like medicine, economics or law look different. From the very beginning, these studies have been filled with a certain level of science and anyone working in this field has studied this science to a certain extent. The fact that agriculture has been, and still can be practiced without any level of education is unfortunately still influencing its image. This is confirmed by the students from developed countries in the interviews.

3. How to improve this image

Promoting the fact that agriculture has an important role in everyone's daily life is a way to improve the current image around agriculture and agricultural sciences. As one of the interviewed students nicely mentioned: "Our job will only disappear when people stop eating." People in the developed world are no longer aware of the link between food and agriculture. Their food comes from the supermarket where there is always abundance and an enormous array of choice. In their perception, food has completely lost its link with the fields where it comes from and with that it has lost its link with agriculture. To quote CIMMYT's Dr. Bram Govaerts "It is our task to bring the pride back to the fields".

The interviewed students mentioned as well that some of their universities were actively trying to promote the role of agronomy in society, but most of them mainly managed to reach those already active in the field of agriculture, not that part of society that is most unaware of the link between food and agriculture. They also said that it should not be seen as the task of the university to increase this awareness, but that this is more the responsibility of governments.

Another aspect that can improve the image of agricultural sciences is changing societal view that everyone working in the agricultural sector is regarded as a farmer. Unfortunately and incorrectly, this farmer is still too easily associated with a lower level of education due to factors mentioned earlier. This influences the whole agricultural sector, also the people with a university degree. Promoting specifically the work of agricultural researchers or agronomists can broaden the image of agriculture.

To conclude: making society more aware of the significance and highly challenging task the agricultural sector is facing, and making them aware of the actual figures on the increase in food production that will be necessary, is an important factor in improving the image of agriculture. Currently there does not seem to be a link in society that connects the agricultural sector with the action of "making this world a better place", as mentioned one of the important values for this generation. Yet this is exactly the reason why Dr. Borlaug received the Nobel Peace Prize in 1970. Indeed his work and the work of many agronomists with him helped to keep the peace in a region where an enormous famine would have broken out had it not been for their knowledge on agricultural science. Since a second green revolution is needed to feed at least 9 billion people by 2050, similar heroic deeds can be delivered by agricultural practices as has been performed back in the '60s.

All of these aspects come down to the same problem: society does not know enough about the agricultural sector, its achievements, its challenges and the importance of our jobs to everyone, every day. Informing people about the role of agriculture, for example through more media attention, can increase the respect for the sector, can improve the image and in the end can result in a higher number of students interested in the study. Developing countries are an example where society, for unfortunate reasons, is much more aware of the role of agriculture in people's daily lives. At the same time however, these are countries where the agricultural students enjoy relatively a higher social status and where there is a higher percentage of students interested in studying agricultural sciences. These are exactly the changes we would like to see happening in the developed regions.

IV – Career possibilities

As mentioned earlier, the career possibilities in a particular sector play an important role in choosing a field of study. When you start studying, you, most likely, also have the intention to end up working in that same field. The number of available jobs, the job quality, its salary and the job security all play an important role in this decision making. How is the situation for the agricultural sector?

1. Career possibilities according to the students

In the interviews, the students were asked about their thoughts regarding career possibilities for graduates of agricultural sciences in their own country. Almost all students answered very positively about what they perceived were their future opportunities. According to what they heard from graduated students and on basis of the information provided by their respective universities, they believed that studying agriculture and related sciences was a very smart choice. Every single one of them mentions that they see their study as a great investment of both the money and time and none of them regrets their choice. They mentioned that they get the feeling it will be relatively easy to find a job compared to other studies. Only the students from Benin and Uganda mentioned that finding a job after graduation might be hard but unfortunately this is the case for most types of graduates in those countries. There is a division among the students regarding their opinion about the salary and the quality of the available jobs. Especially the South European countries interviewed (Spain, Italy and Croatia) mentioned that it is possible to find a job after graduation but currently the majority of those jobs are mostly practical and not as well paid as other university-levelled jobs.

2. Career possibilities according to the data

This positive feeling of the students about their career possibilities is well reflected in facts and figures related to graduates in the field of agriculture and the ease with which they can find a job.

Let's start with an example from Spain. Figures from Universidad Politécnica de Madrid show that 95% of all agricultural engineers/agronomists that graduate from this university have found a job within 1 year. It is even mentioned that being an agricultural engineer is the profession with one of the highest employability rates in times of crisis (Universia España, 2009), something that can be of great importance for youth in a country that is known for its high youth unemployment rates.

In Belgium, the same trends can be observed. 94% of all students who graduate from the master bio-science engineering have found a job within one year, which is above average compared to all other masters and also compared to other Masters of Science. Only civil engineering has higher employment rates one year after graduation (VDAB, 2013).

Also in Croatia the numbers of employment of agronomists look relatively positive. Compared to all other jobs, agronomists have 9% higher employability rate than the average (Hrvatski zavod za zapošljavanje [Croatian Employment Service], 2012).

To conclude with an example from Poland, data from the Warsaw University of Life Sciences (SGGW) shows that the agriculture related studies (agriculture and food technology) have a higher rate of employment of the graduates after one year than the average number of all graduates from all studies from this university (pers comm., SGGW International Relations Office).

In every of these four examples the employability for just graduated students turns out to be on average higher in the agro-food sector than the average of other sectors. These figures coincide with what the students mentioned in their interviews. With the projected need of increase in food production, the need for agro-food related positions will increase as described in the introduction. Therefore, it is likely that these employability numbers will stay positive for the sector. Promoting the high job security among high school students that are at the point of choosing their study can improve the numbers of students choosing for agricultural sciences.

V – Quality of education

It's of great importance that those few high school students in the developed countries that currently show an interest in studying agricultural sciences and gather more information about the study itself, also actually end up studying it. For this group of students, the quality and the attractiveness of the education itself matter.

1. Curricular

In the interviews, the students were asked their opinion regarding the quality of their particular study. Since the outcome is, naturally, strongly dependent on university, the type of education and the study itself, a generalized answer can't be given. Their respective answers can be found in the annex. They were also asked about what, in their eyes, makes a study a good study. One of the comments that came back was that part of the content of the study should be adapted to the current topics in society. Especially in our agro-food sector this is interesting since there is a lot happening in this field. For example, the rise in popularity of organic products and with it all types of judgements against conventional agriculture. What has our science to say on these issues? The interviewed students mentioned to appreciate it if these types of topics were implemented in their study to create a direct link between their education and the societal debate on these topics.

2. Extra – curricular

Next to the courses taught in a study, also the extra-curricular opportunities like internships, guest lectures or opportunities to attend conferences matter with regard to quality and attractiveness of a study.

Since all interviewed students are members of our international student organisation and most of them are active participants of the international events IAAS organises, their answers may be biased.

All the interviewees agreed to the fact that extra-curricular activities are a great extension to the study and that it increases the attractiveness of it a lot. By actively taking part in these types of activities, they say you get more directly involved with all the interesting things going on in the agro-food sector, increasing your commitment for both your study and also these external activities. Fortunately, the range of extra-curricular opportunities that is available to agriculture related students are numerous. Not only are they organized by universities or the students themselves but there is an increasing trend of big international events organized by different organisations that address the upcoming food security problems and try to get youth actively involved in finding solutions for this problem. Examples include the yearly *Thought For Food Global Challenge (www.tffchallenge.com)*, the *Youth Ag-Summit* (*www.youthagsummit.com)* in Canberra this summer and also the 2014 *Google Science Fair* (*www.googlesciencefair.com*), which was won by three 16 year old Irish girls with a project to "combat world hunger".

Also in this aspect of the study lays the opportunity to greatly improve the way of making promotion to attract more students. Even though these activities provide such a valuable extension to the courses in a study, the majority of the interviewed students mentioned that they were not aware of the possibilities of attending extra-curricular activities when they were choosing their study. They say it has been a very pleasant surprise to them, an extra gift coming along with their choice of study.

VI – Conclusion

To increase the number of students that choose to study agriculture or related sciences, several actions can be taken.

Firstly, an improvement of the image of agriculture and its sciences is needed. Making people more aware of the role of agriculture in our daily life's, of the challenges all of us are facing regarding food security in the future and of the many different aspects the farm to fork chain contains, is a way to increase awareness of the importance of the sector, improve its images and with it possibly attract more young people.

Furthermore, both the career perspectives as well as the extra-curricular activities available for the agro-food sector are very positive. Advertisement of these aspects along with the promotion of the study itself among the youth that is about to choose their study is a way to increase the popularity of the study and win the battle from currently more popular studies.

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Annex 1 – Questionnaire and answers

1. Questions

1. Social Status

1.1 How is the awareness of the society in your country about the fact that we are facing a major World Food Problem? Do people know this?

1.2 Is your university actively promoting the role and importance of agronomy (the science) in your society.

1.3 How many students in your high school class considered studying agriculture? (Doesn't need to have been their actual choice, but at least showed some interest. %)

1.4 In your university, are the agricultural related students among the "cool-kids", are they being looked down on, or something in between?

2. Curricular

2.1 Do you think your university adapts the content of your study to the needs of society?

2.2 Do you feel confident you will have an interesting, secure and well paid job after graduation?

2.3 Does your university in cooperate the student wishes regarding contents of the curricula? If yes, how?

2.4 Do you think what you learn in your study will be useful in your future job. (%)

3. Extra-Curricular

3.1 Do you think that at your faculty there is a sufficient range of extra-curricular activities offered in the field of your study (e.g. guest lectures, science competitions, conferences, internships, IAAS activities)?

3.2 Do you think these activities increase the attractiveness of your study?

4. Other

4.1 Is it financially affordable to study? (Tuition fee, availability grants, living costs etc.

4.2 Do you think studying your study is a smart investment both in time and money?

4.3 How is the international student mobility at your faculty? (Erasmus(+), other exchanges) In case currently it's not easy to study abroad for some period during your study, if this would improve, do you think this will have any effect on the attractiveness of your study?

4.4 Did the ranking of your university influence your choice to study there?

2. Answers

2.1 Social status

Country	1.1. Awareness	1.2. Promotion Agronomy	1.3. % considering study ag.	1.4. Cool?
Benin	Yes - suffering themselves	Yes - helping subsistance farmers	15%	Yes
Canada	No - there is abundance	Sustainability is promoted	My school:1/600; in Quebec total 400/year (population: 8 mil.)	Generally: Marginal, but increasingly popular every year
Chile	No	Yes - but its more the task of the gov.	10%	Yes, we're the most popular (coolest parties)
Croatia 1	Not really – importing is cheap	Not much, but it's getting more	10%	Not so cool – middle
Croatia 2	Not really	Promote new techniques, farmers can't afford those	4%	Not so cool – middle
Germany	They have heard about it – doesn't influence their decisions	No	4%	Middle – (coolest parties)
Indonesia	Yes – ^ foodprices have huge impact	Yes	5%	/
Italy	No – there is abundance	Not in the general media, just in ag. Related	2-3 %	No, you're compared to a farmer, not real degree
Mexico	No – only concerned about the prices but don't see the reason of the ^$	Yes my uni does it- but it's more the task of the gov.	1%	Cool! biggest parties; owning a farm =/= being farmer
Spain 1	Yes concerned but don't know about the solution	No, more awareness should be created	4% 1/25	Low technical students. We have to defend ourselves though civil engineers e.g. always directly gain respect
Spain 2	Not much awareness, not much in the media	Inside uni yes, to the rest of society no	1% I just choose it cause didn't know what to do	Cause we do ENGINEERING for this part they have respect. Agronomic part is not thought to be cool
Spain 3	In general ignorant, though not among ag. Students	Yes ! There are events to involve kids more in ag.	0% even me not	From all engineers, we're the easiest. The other engineers don't take us serious

Country	1.1. Awareness	1.2. Promotion Agronomy	1.3. % considering study ag.	1.4. Cool?
Spain 4	Absolutely no, no attention in the media	Due to crisis, little investment in this	10%, only me choose it	Among other engineers at our school not good viewed
Belgium	Not really, not influencing decision making	A bit, often try to get research in the newspaper	1%	Among the engineers, the less cool ones.
Uganda	Majority knows, also high on political agenda but corruption problem	Yes, especially my faculty (Biosuma University)	45%	/
Ukraine	Not really, just own problem	Yes. Our uni is directly under the ministry of ag. And have attention for this	Almost none	Other students look down on us
Zimbabwe	Yes – we suffer ourselves	Yes directly with the farmers, but not rest of societ	All students in my high school who had biology had as only option to study ag	We are admired!!
Nepal	Yes – we suffer ourselves	Only 1 ag. Uni in whole country. They promote only under student	In the country: 80.000; 50 places !!!	High social status – strong selection —> we are smartest
USA	Depends on the type of education	Yes definitely	None except me (even in Ames, hometown of ISU)	Two types: cowboys/hippies. Both not super cool

2.2 Curricular

Country	2.1 adapt content	2.2 confident about job	2.3 incooperate student wish	2.4 usefullness (%)
Benin	Maybe, but too much theory	<20% get a job, <5% get interesting job	No	5-10%
Canada	Yes	Yes confident, but salery is lower than other uni graduates	Yes, every 2 years revised by comments given	A lot
Chile	/	Yes confident	Sometimes	<50%
Croatia 1	Not so much	Yes confident to find but well paid probably not	A bit, initiative comes from the professors	Some usefull / some less
Croatia 2	Yes, a lot of attention to sustainability	Yes, always can start your own farm. Being hired more difficult	Yes, students presented in the board meetings	97% really good content!

Country	2.1 adapt content	2.2 confident about job	2.3 incooperate student wish	2.4 usefullness (%)
Germany	Yes, more stress on ecology etc.	Yes. This is also how the study ispromoted	Try too, input of students is difficult	40%
Indonesia	Yes	Yes. I also learn how to create a job myself	Yes, every end of semester it's evaluated and adapted	Not so much. More softskill needed
Italy	Not so much	There are jobs, but in the field for which you don't need a degree	No, prof. Is the boss	50%
Mexico	Yes, but the target is economy and not sustainability eg.	Immideatly, already can be hired during your study	Supposed to	A lot ! But need more practicals
Spain 1	Yes close relationship, investigations carried out by the faculty	Yes I see great opportunities for next agri graduates	/	Very usefull 100%
Spain 2	Yes try to adapt it, though still traditional curriculum	Yes, I read it in an article	Student board that has the ability to talk with the board	50%
Spain 3	Yes try, but most of the professors are really old fashioned and hard to change what they teach	Absolutely, but not due to my degree but due to extra curricular activities I'm active in	No study plan is closed	10%, but it creates a way of thinking thats far more important
Spain 4	Most of the professors are really old fashioned and hard to change what they teach	Not bad for ag. Engineer but payed bad	Yes try to accurate the program	Yes most of the problems are focused on problems we face in the future
Belgium	Yes, actively ! Now have complete master for WFP	Yes	Yes, student every semester asked for opinion	50% (bach. Not so much)
Uganda	Not really, there is a lack of practicals	It's hard in Uganda, especially childeren of subsistant farmers	Yes they use the input of students in curricula adaptation	Yes it was usefull
Ukraine	/	The ag jobs pay very well and there are international companies	No we live in a regime	/
Zimbabwe	Trying too but it's not moving with the pase it should/	YES ! But problem of corruption, connections are vital	Students in boardmeetings with professors, but ideas not always implemented	90%

Country	2.1 adapt content	2.2 confident about job	2.3 incooperate student wish	2.4 usefullness (%)
Nepal	We learn too high level – not applicable for local community	YES !	Not really, a lot of politics	Not much, too high technology
USA	Definitely	Yes	Yes, for honor students especially they make the curriculum very flexible	50%

2.3 Extra Curricular

Country	3.1 sufficient range	3.2 increase attractiveness?
Benin	Some but practicals are lacking	Yes
Canada	A lot !	Yes, it brings good ambiance at school and among the students
Chile	NOO !	Yes, and it also gives motivation to keep on studying
Croatia 1	Not and not well advertised	Yes
Croatia 2	You have to do internship but there is no network. IAAS helps	Yes
Germany	Not too much, everything organizd by the students themselves	Yes, but the problem so far is it doesn't influence their choice cause students don't know about it when they start studying
Indonesia	Yes	Yes, escpecially IAAS that makes a bridge to the professional world
Italy	No, big problem, no money for this	Yes off course
Mexico	Yes they offer a lot	Yes, marketing should focus on this
Spain 1	There are few, but not encouraged	Totally !
Spain 2	There are some but too few. If students show initiative a lot supported	Yes, it should be more advertised to promote the study
Spain 3	There are a LOT ! But really not well advertised	Absolutetely ! Focus and work more on that !
Spain 4	/	/
Belgium	Yes. Quite ok.	Yes for sure, more promotion needed
Uganda	Not at all, now with new IAAS we hope it improves	If well packaged it can do so
Ukraine	/	/
Zimbabwe	Yes there are many	Not if the message isn't spread different. Now as starting student you don't know about this
Nepal	Nothing: (we want more !	Yes, but not necessary, cause already very popular
USA	Yes, there are a huge number, this is a reason to study ag !	Yes, the possibilities for ag. Students make them create impressive cv's

2.4 Other

Country	4.1 Affordable	4.2 Smart investment?	4.3 International student mobility	4.4 Ranking
Benin	Very expensive, but some UNESCO grants	Yes	Recently intra ACP mobility	No
Canada	12.000$ a year	Yes !	Good, but not much promotion. Also AISEC and IAAS	Yes it mattered
Chile	$8000 a year	Yes	Receive a low no. Of students	No for bachelor not
Croatia 1	Free if you pass all	Yes	Yes a lot of opportunities but: expensive and not matching what is being missed at home	No
Croatia 2	Free if you pass all, also cheap housing available	Totally !	It is easy. More promotion would increase attractiveness	Not really
Germany	Same for all, not so expensive, mainly public transport card	Yes	You miss a semester but easy to go	Not in this case, only if it would have been the worst
Indonesia	Yes expensive	Yes, food always needed	Possible	Yes, national ranking. My campus is best of Indonesia
Italy	Depends on parents income: €500-€2000	Depends, now its difficult to find a job	Yes its easy, thanks to EU money	No, more important how close
Mexico	Private is very expensive, but there are some scholarschips	Yes I would always make the same choice	Yes a lot of opportunities, but its expensive and you don’t get a grant	In general my uni is good, that makes it attractive, not specially my faculty
Spain 1	Costs increase every year and less scholarschip opportunities	Yes	It is easy and encouraged	No, more location mattered
Spain 2	Increase every year	Yes	Yes when you apply pretty much sure you can go	Yes Politécnica is one of the best of Spain
Spain 3	It increased a lot ! 2x more than it used to be. More scholarships needed. Still afordable compaired to other countriesd	Yes	Yes many opportunities	Yes the best uni or engineers of spains
Spain 4	Huge increase of prices and Madrid as a city is expensive to live	Yes for sure	Yes very easy but English level is a problem	Not at all

Country	4.1 Affordable	4.2 Smart investment?	4.3 International student mobility	4.4 Ranking
Belgium	Yes	Yes	Very easy ! Don't miss a semester, grants guarenteed	A bit, but both Ghent and Leuven are good
Uganda	It's difficult	Yes	Trying, but few scholarships. It improves greately the attractiveness	No, the type of courses mattered
Ukraine	No it's expensive and corruption (in total I paid $8000 – in envelop)	Yes	/	/
Zimbabwe	Broad range: from cheap to expensive schools	Yes	Very little places (2 for whole uni)	Not the ranking, only that its private
Nepal	All students in this 1 ag uni get (partly) scholarship, so yes	Yes	Nothing, not even hosting	No, there is only 1
USA	Studying ag. In my college is more affordable	Yes	Yes, but no guaranteed credit transfer (may inmply extra costs, of an extra year of studying)	Somewhat, Iowa State University is well known and offered me good financial support

Session II
Are current Agricultural Educational models suitable to meet global challenges?

Are current agricultural educational models suitable to meet global challenges?
Case study: Japan

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Abstract. The farm workforce in Japan has decreased from 14 million to 2.6 million farmers over the last 50 years. Currently, older people (over 65 years) comprises of 60% of the total farm workforce in Japan. This is very high compared to the total population of Japan, where this age group represents about 20% of the population. Thus, food production in Japan may become threatened in near future unless the farming structure is changed or reorganized. In vocational high schools less than 15% of total students study agriculture, and at universities only 2.5% or 5% of all students study agriculture, at either undergraduate or postgraduate level, respectively. To promote the interest of young students in the actual conditions of agriculture, it might help exposing them to on-farm management and difficulties of farmers in their vicinity. This might help them to better understand real farming problems and their potential solutions. University teachers and researchers also need to acquire and maintain sufficient practical skill suitable for teaching a practical curriculum. Nagoya University started a capacity building program for undergraduate students providing overseas study tours, while the Japanese Government supports capacity building of graduate students and young researchers via the Science and Technology Research Partnership for Sustainable Development (SATREPS) program. These are new initiatives designed to encourage young people to study sciences to solve farming problems.

Keywords. Agriculture – Capacity development – Farming – Field study – Practical science – SATREPS.

Les modèles éducatifs actuels relatifs à l'apprentissage de l'agriculture sont-ils adaptés aux challenges de la mondialisation ? Etude de cas : Le Japon

Résumé. *Le secteur agricole japonais a vu sa population décroitre de 14 millions à 2,6 millions au cours des 50 dernières années. Actuellement, 60% de cette population est âgée (plus de 65 ans) ; un taux très élevé si on le compare à celui de la population totale du Japon pour la même catégorie d'âge qui est d'un peu plus de 20%. Dès lors, le secteur agricole risque de faire face à de graves problèmes dans un futur très proche s'il ne change ou ne se réorganise pas. Seul 15% des lycéens présents dans les lycées techniques et professionnels suivent une formation aux métiers de l'agriculture, et au niveau universitaire ce sont seulement 2,5% et 5% respectivement qui participent aux programmes de premier et second cycle d'études agricoles. Exposer les jeunes étudiants aux réalités de la vie agricole et organiser des rencontres avec les agriculteurs pourrait être un moyen de susciter leur intérêt pour les sciences liées à l'agriculture et leur faire comprendre les problèmes à résoudre dans ce secteur. De même, les enseignants et les chercheurs doivent suivre une formation les mettant directement au contact du terrain qui leur permettra d'encore mieux éduquer leurs élèves. L'université de Nagoya a débuté un programme de formation des capacités destiné aux étudiants de premier cycle avec voyage d'étude dans différents pays étrangers et le gouvernement japonais apporte son soutien aux jeunes chercheurs et aux étudiants de second cycle à travers le programme de partenariat de recherches scientifiques et technologiques pour le développement durable (SATREPS). C'est ce genre de nouvelles initiatives qui incitera les jeunes générations à étudier directement au contact du terrain.*

Mots-clés. *Agriculture – Développement des capacités – Travaux de ferme – Etude(s) au contact du terrain – Science pratique – SATREPS.*

I – Introduction

Today, Japan is not an exception from the other most developed countries; fewer and fewer young people are interested in agricultural studies. In this report, I intend to clarify or explain the evolution of agricultural education figures in Japan and some attempts of Japanese universities to educate young students, aiming at the stimulation of those students to work in the agricultural sectors in some way in the future in order to assure the food security not just for Japan but also for the world. I will start with the overview of agricultural production and human workforce problems surrounding agriculture and vocational education of high schools of Japan.

II – Overview of farm workforce and food production in Japan

1. Population and farm workforce

In the 1960s, over 14 million Japanese and about 6 million Japanese households (2.3 persons/household) were engaged in agriculture (Fig. 1). The workforce declined gradually to 2.6 million workers in 2.5 million households (1.0 persons/household) in 2010. The ratio of farm workforce to total population of Japan was 9.9% in 1970 and decreased to 2.6% in 2010 (Fig. 2). During that period, the total population of Japan increased gradually from about 105 million in 1970 to 124 million in 1990 and then slightly to 128 million in 2010 (Fig. 2). This means that less and less farmers have been engaged in agriculture in the past 40 years. Furthermore, Fig. 3 shows that the aging rate (percentage of people aged over 65 years old against total population) is less than about 20% in the whole country although it increased gradually from 7.1% in 1970 to 23% in 2010. On the contrary, for the farm workforce, the rate was over 50% in 2000 and increased gradually to 63.7% in 2014. The declining of farm workforce and its high aging rate is becoming a serious problem in Japan, and this trend will get worse in the near future.

2. Agricultural production and food-self sufficiency rate

In the 1960s the farmland area was about 6 million ha and it decreased to about 4.5 million ha in 2012 (Fig. 4). Gross agricultural product in Japanese yens reached the peak in 1985 – 11,630 billion yen – then decreased gradually towards 2010 and has been recovering a little thereafter. Food self-sufficiency rate in calorie-base which is the rate of domestic food calories/capita/day against total consumed food calories/capita/day, was 73% in 1965 in Japan but was decreasing gradually since then and became smaller than 40% in 2010 (Fig. 5). Japan imports a large amount of foodstuffs, for example, 88% and 93% of total consumption of wheat and soybean, respectively, was imported in 2013 and feedstuff such as maize is also imported largely. Food self-sufficiency rates of several developed countries such as Australia, France, Germany, Spain, UK and USA, are also shown in the Fig. 5 as a reference. Since the 1980s Japan's self-sufficiency rate has been the lowest of all of these countries.

III – Agricultural higher education in Japan

1. High school

Agricultural education is a part of the vocational education at Japan's high schools. Farm technologies as well as theory are taught to students through practical work. Agronomy, horticulture, animal science, food science, agricultural environmental engineering, gardening and bio-engineering are curricula commonly taught at agricultural high schools (Hyogo Prefectural Agricultural High School, 2015). Graduates get jobs related to agriculture in some sense and some of them go for further education. The number of students studying at the vocational high schools has been de-

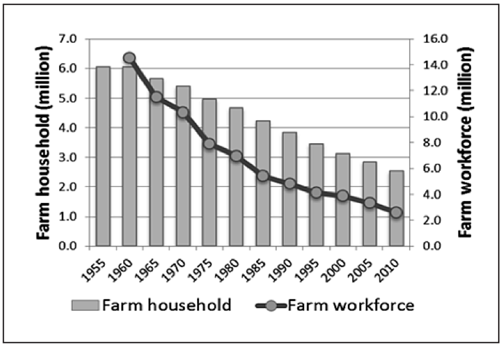

Fig. 1. Farm workforce and farm households of Japan, 1955-2010.

Source: Ministry of Agriculture, Forestry and Fisheries, Japan, Agricultural Census 1904-2010.

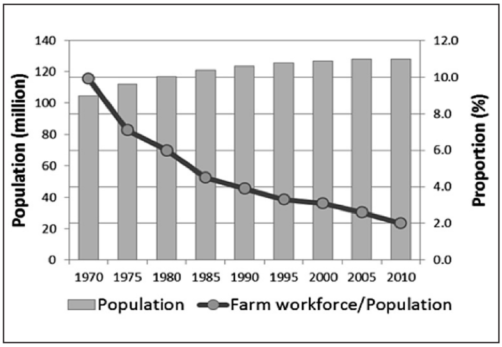

Fig. 2. Population and farm workforce/population ratio of Japan, 1970-2010.

Source: Ministry of Agriculture, Forestry and Fisheries, Japan, Agricultural Census 1904-2010 and State of Rural Area and Farm Villages 2011.

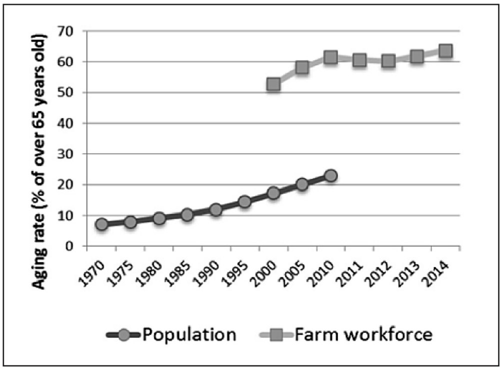

Fig. 3. Proportion of aged people in population 1970-2010 and in farm workforce 2010-2014.

Source: Ministry of Agriculture, Forestry and Fisheries, Japan, State of Rural Area and Farm Villages 2011 and Statistics of Farm Workforce 2014.

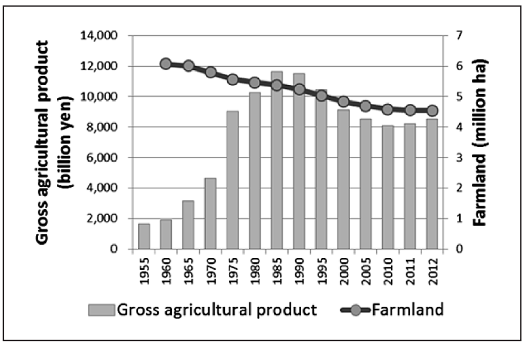

Fig. 4. Farmland area and gross agricultural product, 1988-2012.

Source: Ministry of Agriculture, Forestry and Fisheries, Japan, Statistics of Gross Agricultural Product 1955-2012 and Statistics of Farmland and Cultivated Area 1956-2012.

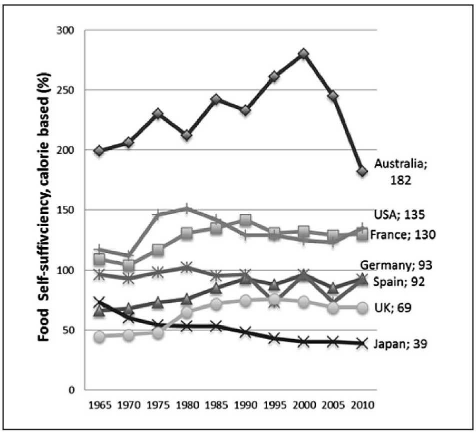

Fig. 5. Food self-sufficiency rates of several developed countries, 1965-2010.

Source: Ministry of Agriculture, Forestry and Fisheries, Japan, Food self-sufficiency rates of the world.

creasing in recent years and in 2014 just over 20% of the total students studied at vocational schools (Fig. 6). Most students prefer studying at the general or comprehensive high schools, hoping generally to go for higher education at the university, vocational college, etc. Agriculture is not a main course of vocational education; the ratios of students in agriculture, industry and commerce are about 13, 41 and 33%, respectively, of the total (Fig. 7). Figures 8 and 9 show the changes in number of high schools and their students, respectively, since 1955. It is surprising to note that the number of agricultural high schools (agriculture + fishery), decreased drastically from 1321 in 1960 to 353 in 2014 (73% decrease), whereas total number of high schools decreased to 7,227 in 2014, just about 18% less than that in 1960 (Fig. 8). The same tendency is observed in the number of high school students and the number of agriculture and fishery students which has stagnated at low levels, between 90,000 and 100,000, since 2005 (Fig. 9).

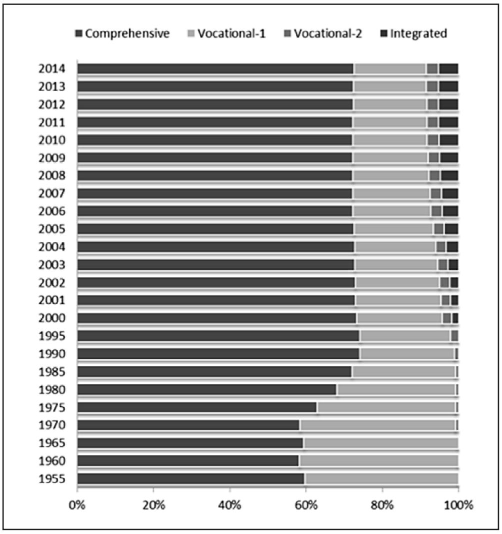

Fig. 6. Education types of high schools in Japan, 1955-2014.

Vocational 1: agriculture, engineering, commercial, fisheries, homemaking, nursery, information, welfare.

Vocational 2: science/mathematics, gymnastics, music, art, foreign languages, international relations, etc.

Source: Ministry of Education, Culture, Sports, Science and Technology, Japan, Basic Statistics of Schools 1948-2014.

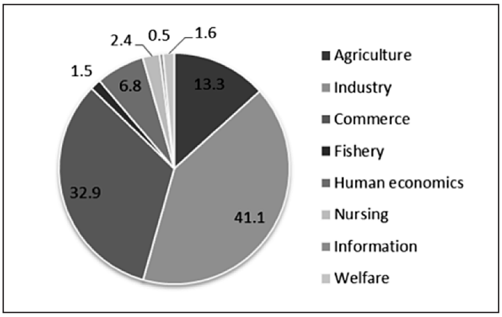

Fig. 7. Students (%) in various vocational high schools in 2014.

Source: Ministry of Education, Culture, Sports, Science and Technology, Japan, Basic Statistics of Schools 1948-2014.

2. Undergraduate and graduate university programs

The ratio of undergraduate students of agriculture declined from 4.5% in 1960 to 2.6% of all students today. The number of agricultural students is about 75,000 in these years out of a total of 2.9 million students at the university undergraduate programs (Fig. 10). On the other hand, in the recent years over 8,000 students study masters programmes on agriculture, and just below 4,000 follow agricultural doctorate programmes; this means only 5% of the total graduate students (Fig. 11). This increase in students ratio at the graduate school compared with that of the undergraduate school may be the result of universities' efforts. Around late 1980s to 90s, many national uni-

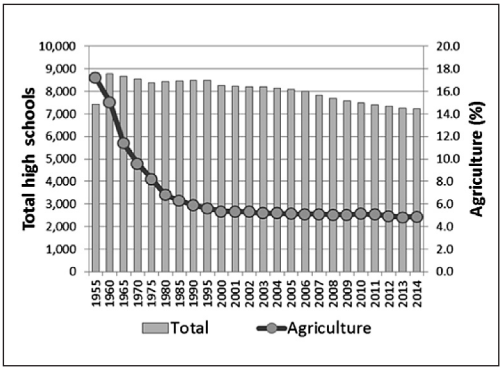

Fig. 8. High school number and proportion of agricultural high schools, 1955-2014.

Source: Ministry of Education, Culture, Sports, Science and Technology, Japan, Basic Statistics of Schools 1948-2014.

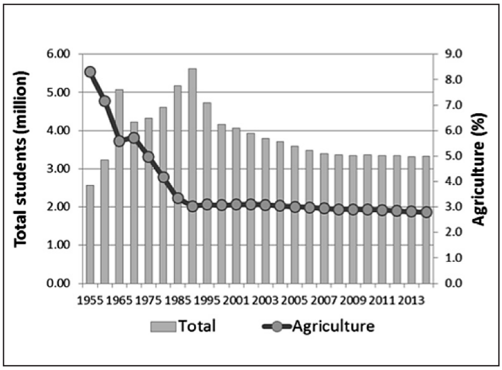

Fig. 9. Total high school students and proportion of agriculture students, 1955-2014.

Source: Ministry of Education, Culture, Sports, Science and Technology, Japan, Basic Statistics of Schools 1948-2014.

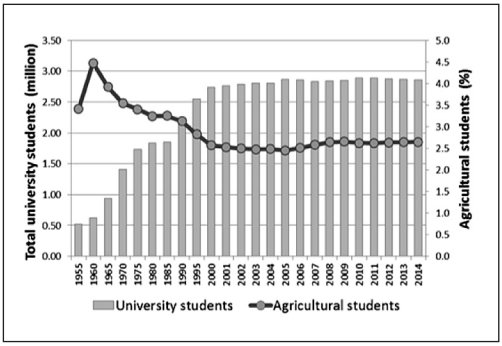

Fig. 10. Total university students and proportion of agricultural students, 1955-2014.

Source: Ministry of Education, Culture, Sports, Science and Technology, Japan, Basic Statistics of Schools 1948-2014.

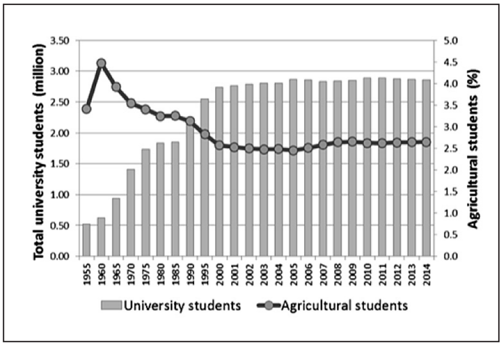

Fig. 11. Agricultural graduate students and its proportions to total graduate students, 1955-2014.

Source: Ministry of Education, Culture, Sports, Science and Technology, Japan, Basic Statistics of Schools 1948-2014.

versities changed their schools or faculties names from agriculture to agricultural science, applied biological science, life science, life and environmental science, bio-resources, bioagricultural science, bioenvironmental science, biosphere science, etc.; in a context a tendency of loss of interest in agriculture among high school students and decline in the number of children, this change probably intending to absorb more students by providing human society- and/or life-related sciences and rather basic science, more than an application in agriculture.

Nowadays, about 75% of agricultural graduates of Nagoya University go to the Master's program seeking for higher qualification for the job market (Fig. 12a). Only 14% of Master graduates go to doctorate programmes, while most of the others get jobs in the private or the public sectors (Fig. 12b). Doctor graduates, most likely PhD holders, start working as researchers at either private or public positions (Fig. 12c).

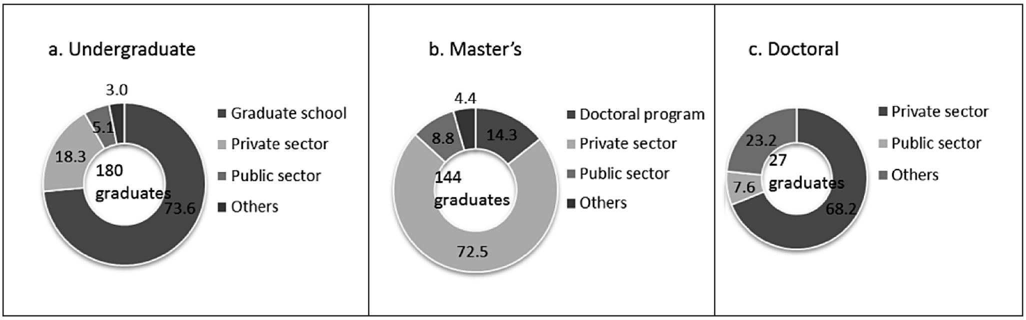

Fig. 12. Various tracks for the graduates of agricultural undergraduate and graduate programs of Nagoya University (Percent (%) of means for 2005-2014) a. Undergraduate, b. Master's program and c. Doctoral program.

Source: Graduate School of Bioagricultural Sciences, Nagoya University, 2015. Students Statistics 2005-2014.

3. Situation of present agricultural education at most universities in Japan

It is important to emphasize that a part of the education at the university is performed through conducting research. Therefore, the level or content of the research, basic science or practical science, will definitely influence the education. The word 'agriculture' has two meanings that are 'practice of farming' and 'science of farming' (Longman Advanced American Dictionary, 2000) or 'the science or art of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation of these products for man's use and their disposal (as by marketing) (Webster's New Collegiate Dictionary, 1979). Thus, agriculture is supposed to be a practical science led to the development of agricultural technologies and so it is expected to solve the practical farming and livestock problems, aiming to improve plant and animal performance and ultimately improve profitability and sustainability of the entire enterprise. It was true in the past but since considerably long time ago, agriculture has extended from practical science to rather basic science and nowadays more and more researchers of universities and agricultural research institutions, particularly in Japan as well as in other developed countries, tend to engage in basic science research. As a result, students will most likely be educated with the basic science of agriculture, which might be one of the reasons why students lose interests or could not intrigue interests in agricultural studies. However, students need to be exposed to the agricultural practices or actual conditions of farmers to understand the problems to be solved by research.

4. How can students have interests in agriculture?

First of all, students need to be exposed to the reality of agricultural production through farmers' field observation and interview or discussion with farmers and villagers so that they could understand the problems in agricultural production and village life and eventually the purpose of agricultural research as a practical science. Then, as a result, they could be expected to find interest in the study of agricultural.

However, in reality, at Nagoya University, laboratory techniques such as molecular, biological, chemical analysis, instrumental analysis and many other techniques commonly used in agricultural research are being taught presently. Some students are obliged to take a curriculum, farm practice (1 year) at the university farm, to learn field experiments to grow and take observations of rice, livestock and other crops. However, until very recently, they did not have a chance to go to farmers' fields to take observation of what is going on there and interview or discuss with farmers on their life or problems of farming. There were not many teachers/researchers who had interests in such a curriculum as well. Consequently that subject was not included in the curriculum, and resulted in producing students being rich in analytical techniques and knowledge but having poor idea of agriculture in terms of food production, crop and livestock protection, soil fertility management and so on.

IV – New approaches towards education of practical agricultural study

1. Overseas study tour of undergraduate students

Nagoya University started a new curriculum for the undergraduate students in 2009. Students visited the Royal University of Agriculture (RUA) of Cambodia and the Kasetsart University of Thailand, under the guidance of accompanying teachers/researchers who have long experience in working in the fields of education of those countries, and exchanged experiences with RUA and Kasetsart University students. They visited villages with teams of students of those countries for taking observations, interviews with farmers and made their own considerations after knowing the facts of farmers and farming. Even though the tour was not long, just about 10 days at first, it was a big surprise for the accompanying teachers/researchers to find students opening their eyes to agriculture and becoming more interested in the study of agriculture than before. We noticed that giving chances to Japanese students to be exposed to real agriculture and agricultural problems would be really helpful to drive students towards the agricultural study. This program has continued until now and more and more students are willing to participate recently.

In addition, since a few years ago, RUA and Kasetsart University students from Cambodia and Thailand, respectively, have started visiting Nagoya University and similarly villages and farmers in Japan, which means that the mutual student exchange has started. Nowadays, to attend and guide the students, more and more teachers/researchers are required and expected to make positive participation and to do that they need to train themselves first so that they are able to find problems and solutions in the fields, an important entry point to field science or practical science. Teachers first, then students will learn.

2. Education through the overseas research collaboration between Japan and developing countries: SATREPS

Agricultural technologies which are commonly and widely used in the developed countries may not always be adopted in the developing countries for various reasons. This means that agricultural productivity in those countries remain comparatively low despite the many technologies available in developed countries. That is to say, the potential in improving agricultural productivity and enhancing agricultural production is likely to be high in the developing countries in general if technologies are shared. Agricultural technology is locality-specific by its nature and so the development of new adaptive technologies in the locality or the adaptation of available technologies to that particular locality must be tested in the developing countries. The Japanese Government has been supporting the research collaboration between Japanese researchers and counterpart researchers of developing countries, aiming at solving the global scale problems such as bio-resources and its utilization, environment/energy, disaster prevention and mitigation and infectious diseases control. Through this program, human capacity development is highly expected, that is to educate young Japanese researchers as well as counterpart countries' researchers to solve the problems on the ground. The program is called the Science and Technology Research Partnership for Sustainable Development (SATREPS) the outline of which is as follows:

SATREPS is a Japanese government program that promotes international joint research. The program is structured as a collaboration between the Japan Science and Technology Agency

(JST), which provides competitive research funds for science and technology projects, and the Japan International Cooperation Agency (JICA), which provides development assistance (ODA). Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefit to both local and global society.
(http://www.jst.go.jp/global/english/index.html).

V – Towards human capacity development for meeting global challenges

To enhance food security not only of Japan but throughout the world, we must give priority to capacity development. To solve the problems requires knowledgeable people with passion and a clear sense of purpose. To do so, it is urgently needed to educate young students towards practical science of agriculture. For promoting and supporting such education, teachers/researchers of the university need to make efforts to promote interest in the field science and train themselves to find the problems and solutions by being exposed to agricultural fields in general but particularly in farmers' fields the first. Japan is now ready to support such education by promoting international research collaboration with developing countries.

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Tertiary agricultural education in Australasia: where to from here?

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Abstract. Agriculture, i.e. the ability to provide food reliably and efficiently for all, will remain the backbone of our economies. Although the relative economic importance of agriculture has diminished over time, its social and political importance has never been questioned. This special status of agriculture as a pillar of our societies means that we need to pay close attention to the way we teach and deliver agricultural curricula at university level. Agriculture is particularly important in Australasia, a region at the edge of SE Asia, where rapid population growth and demographic changes are putting unprecedented pressures on food systems. This paper examines the current state of tertiary agricultural education in Australasia and highlights some of the foreseeable trends that will drive educational policies for the next few decades. We conclude that the two major regional economies, Australia and New Zealand, share a responsibility and a desire to provide modern and forward-looking curricula that will equip graduates with relevant skill sets and make them 'employment ready'. In Australia such graduate attributes have recently been negotiated via a broad, consultative process that resulted in the *Agriculture Learning and Teaching Academic Standards* (AgLTAS). The standards describe the nature and extent of the agricultural discipline as well as a set of Teaching and Learning Outcomes (TLOs) that were identified by potential employers as 'business critical': Knowledge, Understanding, Inquiry and Problem Solving, Communication and Personal and Professional Responsibility. Australia and New Zealand also have the governance and institutional infrastructure that will allow them to act as educational hubs for the region and be responsive to the training and development needs of their nearest neighbours. This should also assist countries such as Fiji and Papua New Guinea to reform their curricula and upskill their accademic workforce. Continuous and rapid changes in information technology requires constant curriculum review and renewal. Concepts such as on-line delivery, blended learning and flipped classrooms need to be part of curriculum delivery. A greater emphasis on pre-degree delivery and a greater responsiveness to articulated business needs is required to meet industry demand for a well-educated and skilled workforce. Satisfying market demands in the pre-degree space can create pathways for a future university education. The role of universities in providing tertiary education in agriculture that is aligned with market needs will require flexibility from administrators, staff, curriculum developers, industry and students.

Keywords. Tertiary agricultural education – Curriculum reform – Agriculture Learning & Teaching Academic Standards (AgLTAS) – Australasia.

L'éducation tertiaire agricole en Australasie : Où allons-nous à partir de là ?

Résumé. *L'agriculture, c.-à-d. le fait de pouvoir nourrir toutes les personnes de façon sûre et efficiente, sera toujours le pivot central de notre économie. Bien que l'importance économique relative de l'agriculture ait diminué au fil du temps, son importance sociale et politique n'a jamais été remise en question. Ce statut spécial de l'agriculture en tant que pilier de nos sociétés signifie qu'il est nécessaire d'accorder une attention spéciale à notre manière d'enseigner et de délivrer les programmes d'études en agriculture au niveau universitaire. L'agriculture est particulièrement importante en Australasie, une région située à partir de la pointe de l'Asie du*

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Sud-Est, où une croissance rapide de la population ainsi que des mutations démographiques provoquent une pression sans précédent sur les systèmes alimentaires. Cet article fait l'état des lieux de l'enseignement agricole tertiaire en Australasie et met en relief certaines des tendances prévisibles qui configureront les politiques éducationnelles sur les décennies à venir. Notre conclusion est que les deux grandes économies régionales, l'Australie et la Nouvelle-Zélande, partagent la responsabilité et le désir d'offrir des programmes d'études modernes et tournés vers l'avenir permettant aux diplômés d'acquérir un ensemble d'aptitudes essentielles et les rendant aptes à occuper un emploi. En Australie, ces attributs que doivent posséder les diplômés ont récemment été définis à travers un vaste processus consultatif qui a débouché sur les normes AgLTAS (Agriculture Learning and Teaching Academic Standards). Ces normes décrivent la nature et l'étendue de la discipline Agriculture ainsi qu'un ensemble de Résultats d'Enseignement et d'Apprentissage (Teaching and Learning Outcomes – TLOs) qui ont été identifiés par les employeurs potentiels comme cruciaux dans le monde des affaires : Savoir, Compréhension, Investigation et Résolution de Problèmes, Communication et Responsabilité Personnelle et Professionnelle. L'Australie et la Nouvelle-Zélande possèdent également la gouvernance et l'infrastructure institutionnelle qui leur permettront d'agir en tant que pôles éducationnels pour la région et de répondre aux besoins de formation et de développement de leurs plus proches voisins. Ceci devrait également être d'utilité à des pays tels que les îles Fidji, la Papouasie et la Nouvelle-Guinée, pour réformer leurs plans d'études et remettre à niveau leur personnel académique. Les changements continus et rapides de la technologie de l'information exigent une révision constante et une rénovation des plans d'études. Des concepts tels que formation en ligne, formation semi-présentielle et classes inversées devront faire partie des programmes d'études délivrés. Il sera nécessaire d'insister davantage sur la formation pré-universitaire et sur une plus forte réponse aux besoins exprimés par le monde des affaires pour satisfaire la demande de l'industrie dans le sens d'une force de travail mieux formée et plus compétente. Satisfaire les demandes du marché dans l'espace pré-universitaire peut créer des parcours pour un futur enseignement universitaire. Le rôle des universités en vue d'apporter un enseignement tertiaire pour une agriculture qui s'aligne sur les besoins des marchés nécessitera une flexibilité de la part des administrateurs, du personnel, des développeurs de programmes d'études, de l'industrie et des étudiants.

Mots-clés. *Enseignement tertiaire agricole – Réforme des programmes d'études – Enseignement et Apprentissage de l'Agriculture – Normes Académiques AgLTAS – Australasie.*

I – Introduction

1. Geo-political context

Australasia is the largest sub-region of Oceania (>10,000 km^2) and comprises the four countries with the highest populations in the region: Australia (23.0 M), Papua New Guinea (7.3 M), New Zealand (4.5 M) and Fiji (0.9 M), plus several small island states. The countries' economic development and prosperity have strong foundations in their agricultural sector (Table 1). Economically, Australia and NZ dominate in the region, having highly developed agricultural sectors and agri-businesses, in contrast to PNG and Fiji, where agriculture is still largely subsistence and small scale.

2. Background

The development of agriculture over 10,000 years ago has resulted in a transformational shift in human behaviour, thereby creating the basis for our civilisations. The efficiencies created by agriculture – the ability to reliably feed growing populations with fewer and fewer farmers – meant that no society has ever turned away from it (Leith and Meinke, 2013). Agriculture provided the foundation on which other sectors of the economy could develop and grow. As a consequence, the contribution of agriculture to large, highly developed economies today is only about 1-3% of GDP (Table 1). This demonstrates the incredible efficiencies created by modern agriculture.

However, the proportionally low farm gate contribution of agriculture to developed economies' GDPs does not diminish the strategic importance of the sector. As a direct result of the efficiencies cre-

Table 1. Percent of agriculture as a contributor to GDP based on farm-gate value as well as current population numbers for a range of countries; Australasian countries discussed in more detail in this paper are highlighted in red (World Bank, 2015)

Country	% of GDP	Population (million)	as of
UK	0.7%	64	2013
Germany	0.9%	81	2013
Japan	1.2%	127	2012
USA	1.3%	316	2012
France	1.7%	66	2013
Netherlands	2.0%	17	2013
Australia	2.5%	23	2013
Brazil	5.7%	200	2013
New Zealand	7.2%	4	2010
China	10.0%	1,357	2013
Fiji	12.2%	>1	2013
Indonesia	14.4%	250	2013
India	18.2%	1,252	2013
Vietnam	18.4%	90	2013
Papua New Guinea	36.3%	7	2012

ated by agriculture, the global population has grown exponentially and is projected to exceed nine billion people by 2050. This is equivalent to an annual increase of approximately 60 million, roughly the population of modern Italy. Furthermore, when accounting for the value-adding processes that food and fibre go through once they leave the farm, along with the value of all the economic activities that support farm production through farm inputs, food manufacturing, transport and logistics, wholesaling and retailing and the food service sector, agriculture's contribution to Australia's GDP increases to around 12% or $155 billion (National Farmers Federation, 2015).

For the first time in history, more than half the global population now live in cities rather than rural communities. Increasing urbanisation means that more people will directly compete with agriculture for access to resources such as land, water, capital, labour and infrastructure, particularly across Asia where over half of the world's population now live. As a result of these demographic changes, the increase in the demand for agricultural produce is projected to rapidly exceed the increase in supply, putting additional pressure on the environment and the global food system.

The potential social consequences of these pressures were well captured by English Parliamentarian Lord Cameron of Dillington who, in relation to Britain's food security concerns in the early 2000s, quipped, "we are all only nine meals away from anarchy". As we have recently seen, social orders break down quickly when food supplies are disrupted (Breisinger *et al.,* 2011). A recent report by DAFF (2012) points out that most Australian households hold sufficient food for only 2-4 days (i.e. the 'nine meals' referred to by Lord Dillington).

In other words: while the relative economic importance of agriculture has diminished over time, its social and political importance has never been questioned. It is this special status of agriculture as a pillar of our society that requires a strong and on-going focus on tertiary agricultural education.

Modern agriculture has become a knowledge-intensive sector of considerable societal relevance as evident by the increasing global concern about food security. For instance, Australia's agriculture currently feeds an estimated 60,000,000 people worldwide (National Farmers Federation, 2015). It has been estimated that an upper limit of Australia's capacity to supply food with current technologies will be a 3-fold increase over current production volume. This means that Australia's maximum capacity is feeding approximately 3% of the world's population – an important contribution, but hardly the 'food bowl' proclaimed by some (ANZ, 2012; DAFF, 2013). Yet, the ANZ report highlights that Australia and New Zealand combined could more than double their real value of annual agricultural exports by 2050. This would result in an additional, combined US $500 billion of revenues over the next four decades.

For such sectoral expansion to eventuate requires a strong focus on agricultural education. Hence, we must overcome an ingrained image problem that has plagued the sector for several decades: this image problem is epitomised by the widely-held misconception that to study agriculture means to study farming. This fails to recognise that agriculture is an economic sector that spans the entire value chain from farmer to consumer. The bumper sticker "Agriculture – without us you are dead" says it all. It is no accident that the issue of food security has begun to dominate some political agendas. In a recent report "Building the Lucky Country", Deloitte (2014b) labelled 'Agribusiness' as 'Australia's forgotten hero', a sector ideally placed to capitalise on a world-wide leap in demand for higher-value food products.

In terms of tertiary education we need to accept that agriculture is not a discipline with neatly defined boundaries. It cannot be taught the way we teach mathematics, chemistry or computing. To study agriculture means to study all of the natural sciences plus a lot more, such as engineering, economics, business and law. This is increasingly recognised and reflected in the design of modern agricultural curricula.

II – Overview of Tertiary Agricultural Education in Australasia

Australia and New Zealand are the two major providers of agricultural research and education in the region. Their agricultural sectors are characterised by the use of modern technology, a high degree of mechanisation (a direct consequence of high labour costs), scale efficiencies and a strong research – teaching – industry nexus.

Australia has 43 universities (Australian Government, 2015a). In 2007, those universities that offered a degree course in agriculture or related areas formed the Australian Council of Deans of Agriculture (ACDA) as the peak body for higher education in agriculture. Fifteen Australian universities offering agricultural education and research programs are current members of the ACDA. Member universities are spread across every Australian State and in both metropolitan and rural locations and are listed on the ACDA website. Their course offerings are wide and varied.

New Zealand has eight universities spread across its two main islands. Two of those, Lincoln University in Canterbury (near Christchurch) and Massey University, with campuses in Palmerston North, Albany (in Auckland), and Wellington have strong agricultural offerings (Universities New Zealand, 2015). Having its origin as a School of Agricultural Science formed in 1878, Lincoln is the only university in the Austral-Pacific region that fundamentally has agricultural roots.

The University of the South Pacific (USP) has its main campus in Fiji (Laucala) with smaller campuses in twelve other Pacific Island nations. They offer two three-year degrees: a Bachelor of Agriculture with two streams in Agribusiness and Applied Science at the Alafura campus in Samoa and a Bachelor of Commerce (Agricultural Economics and Agribusiness) at the Laucala campus in Fiji. Employment opportunities for graduates outside the public sector are scarce as a consequence of the small-scale, subsistence-style agricultural systems that are further impeded by prohibitively high transport costs due to the island's remote location and small size.

Only three of PNG's six universities offer degree-level agriculture. Similarly to Fiji, career prospects outside the public sector are scarce. Anecdotal evidence indicates that all institutions suffer from low funding levels and poor maintenance. The Australian Overseas Development Assistance

(ODA) program through the Department of Foreign Affairs and Trade (DFAT), as well as the New Zealand ODA program, offer several higher degree by research scholarships that are effectively training future scientists and research managers.

III – Australia, a case of "lies, damn lies and statistics"

Over 10 years ago Australian agribusinesses began to complain seriously about a shortage of agricultural graduates. A closer look quickly demonstrated that the perception of the value of an agricultural education amongst policy makers, the general public and career advisors bore little resemblance to reality. While policy makers – on the basis of erroneous data – assumed that there was an oversupply of agricultural graduates, the general public and career advisors had a "muddy boots" and "rusty tractor" view of agriculture.

Although the report by McColl *et al.* (1991) into agricultural and related education had highlighted a looming shortage of agricultural graduates, very little was done to redress this and graduate numbers continued their decline until 2012. In 2007, sixteen years after the McColl Report was published, a colloquium was held in Adelaide to consider the paucity of agricultural graduates entering the workforce. Universities were blamed for the lack of graduates yet industry itself had done little to promote careers in the sector. One outcome of that meeting was the formation of the ACDA. This allowed the universities involved in agriculture to speak with one voice on matters regarding agricultural higher education and research. The ACDA accepted the challenge to do what it could to analyse the issue and facilitate an evidence-based debate.

Discussions with the then Federal Minister for Primary Industries revealed that the official position of government was that there were plenty of agriculture graduates and insufficient jobs, diametrically opposed to the views being expressed by industry. The ACDA resolved to collect their own statistics based on their members' graduate data (Pratley, 2008; Pratley and Copeland, 2008; Pratley, 2012). The data clearly showed a decline from nearly 900 graduates in 2003 to less than 450 graduates in 2012. Yet, the employment market was buoyant with up to six jobs for every graduate, although this has softened somewhat in 2014.

Why were official data not identifying the shortage of graduates and why were career advisers under the impression that there were no jobs in agriculture? A more thorough analysis of the official data did provide the explanation. As part of their reporting responsibilities to government, universities provide student data according to categories called 'Fields of Education' (FoE). There are 12 broad FoEs, with 'agriculture, environmental and related studies' being one of them (FoE 05) (Australian Bureau of Statistics, 2001). Although these broad 'two digit codes' are broken down into five so-called 'four digit codes' (e.g. agriculture = 0501, forestry = 0505 and environmental studies = 0509), graduate data are not reported at that greater level of granularity. Hence, a simple question about the number of graduates in agriculture generates a 2-digit response unless otherwise requested. This matters, because graduates in environmental science (FoE 0509) outnumber agricultural graduates (FoE 0501) considerably. For instance, in 2010 about 2200 students graduated in FoE 05; only 413 of those were actual agricultural graduates (Table 2; see Pratley, 2015a,b for more details).

Table 2. Decline in graduate completions for Field of Education 05 (agriculture, environmental and related studies) and for agriculture from 2001 to 2010 (Pratley, 2015a, b)

Source	2001	2010	% decline
Undergraduate completions, FoE05	2991	2207	26
Undergraduate agriculture completions	886	413	53

This scenario repeats itself in relation to salary and employment status. New graduates were surveyed several months after graduation by Graduate Careers Australia, an agency of government. Responses received are classified according to FoE at the 2-digit code. Hence, agriculture is represented by both agriculture graduates and environmental graduates. The latter vastly outnumber agriculture graduates in response and so the combined data are more representative of environmental graduates than of agricultural graduates. This would not matter if the outcomes were similar for both cohorts but that is not the case: agricultural graduates report what is regarded as 'full employment' (>90%), whereas environmental graduates hover between 60 and 70% fulltime employment. When combined, the data show around 70% employment creating a wrong perception of underemployment amongst agricultural graduates (Pratley, 2015b).

These findings generated considerable political and media interest. Numerous enquiries and reviews followed and highlighted the lack of a positive image for agriculture, the perception that agriculture related only to farming, the negativity towards agriculture in the schools and the complacency in the education system and the community about food security. Pratley (2013) noted that students were actively discouraged from choosing agriculture as a career by school career advisors who perceived there were to be no jobs or career prospects. Careers in agriculture were being portrayed as unattractive and unrewarding with low student enrolments consequently threatening the viability of many agricultural degrees throughout Australia. Decades of low enrolment numbers have, of course, taken a toll on a system that relies heavily on student numbers for funding.

Today, agribusinesses have become increasingly vocal about this skills crisis, resulting in intense competition for agricultural graduates. This, in turn, has led to ongoing discussions between employers of agricultural graduates, the Vocational Education and Training (VET) sector (Australian Government, 2015a,b) and universities about pathways, curriculum structure, learning outcomes and desirable skills attributes of graduates.

All sectors responded:

1. Industry and Government realised that the lack of graduates was real, generating concern about its capacity going forward and the impact on future opportunities; issues such as social licence became important;

2. Communities began to wonder about their own food security as the global food security issue was highlighted;

3. The importance of educating children at all levels about food and agriculture was elevated and the significance of organisations such as the Primary Industries Education Foundation Australia (PIEFA) became apparent;

4. The impact on universities of lower enrolments is now a national concern.

Self-appointed industry advisory groups formed to provide universities with proactive feedback about their needs and career opportunities; they articulated a general willingness to assist. Universities across Australia, including some who had previously suspended their courses due to a lack of student intakes, invested in promotion of their degrees (e.g. Australian Broadcasting Corporation, 2012). All these efforts are beginning to show results. Over the last few years, there has been a general increase in enrolment numbers of between 10% and 40%, differing by degree and university. New Zealand is reporting a similar trend and current indications are that this is likely to continue. Students are rediscovering the value of a tertiary education in agriculture. It is now up to universities, in partnership with industry, to ensure that this trend is sustained by an ongoing, continuous curriculum reform process that is responsive to a rapidly changing external environment and new career opportunities for agricultural graduates.

This episode has been a wake-up call for all. There has been an increased urgency towards professionalising the industry – a focus on education and training, a desire to improve the image of the sector, a move towards social licence and greater engagement with future opportunities, challenges and needs. Universities have been an integral part of this increasingly professional approach as the issue of quality in higher education is considered. Learning and Teaching Academic Standard (LTAS) Statements across several disciplines have been published, and are listed as reference points in the national standards framework developed by the Higher Education Standards Panel (Australian Government, 2012).

The increased levels of communication and interaction between industry and universities has led to a new, consultative approach to curriculum development, including the development of national tertiary-level education standards for agriculture to align the expectations of graduates, employers and universities. The standards define the nature and extent of agriculture and outline the key threshold learning outcomes (TLOs). They now inform course development and quality assurance in Australian universities that teach agriculture.

The Agriculture Learning and Teaching Academic Standards (AgLTAS) were developed through national engagement with industry, graduates and academics, including 19 consultation workshops, which were supplemented by an online survey that was available via the AgLTAS project website (Botwright Acuna *et al.*, 2014a). A reference group and project team used Bloom's Taxonomy of Cognition to provide a conceptual framework that guided the analysis and structure of the draft AgLTAS statement (Bloom *et al.*, 1956).

The resultant AgLTAS statement includes a description of the nature and extent of the discipline as well as a set of TLOs that closely reference those for the Science discipline: Knowledge, Understanding, Inquiry and Problem Solving, Communication and Personal and Professional Responsibility. Together these represent what a pass-level graduate in agriculture should know, understand and be able to do upon graduation. Although agriculture fits within science, it also includes core components of business and social constructs not typically captured in the science TLOs.

Industry input was vital in developing the Australian standards to ensure that agriculture graduates leave university with the relevant skills and knowledge. In particular, industry stakeholders highlighted the need for students to demonstrate highly-developed problem solving and communication skills whereas industry/farming specific (vocational) knowledge could largely be gained through on-the-job training both during and after graduation (Botwright Acuna *et al.*, 2014b).

Providers of tertiary-level education in agriculture and related disciplines are encouraged to build on the standards as they design and deliver programs that reflect their particular strengths and priorities. If implemented as a reference point, the standards should support collaborative approaches across the tertiary sector and safeguard each higher education provider's autonomy, diversity and reputation.

This is a crucially important point at a time when major changes to the way we teach and deliver content to students of all ages and backgrounds is underway: these TLOs are not a straight jacket or an attempt at standardising what is rightfully a highly diverse curriculum. Instead they are there as a reminder of what many of us have agreed should be achieved, regardless of the approach or specific content of the curriculum.

Agricultural research and teaching relies on strong links with industry. Without these links, sustainable and profitable practice change in agricultural systems cannot be achieved. Industry representatives considered vocational knowledge of lesser importance to the need for students to attain highly developed problem solving and communication skills that can generate new opportunities and innovation in agriculture. Industry-specific (vocational) knowledge was generally regarded as attainable during on-the-job training after graduation.

IV – New Zealand, big enough to matter, small enough to manage

With only two major providers of tertiary agricultural education and an economy that relies disproportionally on agriculture as a sector (Table 1), New Zealand has several advantages when compared with Australia. These advantages are largely a consequence of New Zealand's much smaller size (this reduces issues related to the "tyranny of distance", which is omnipresent in Australia) and an ability to focus a curriculum on an issue important to most New Zealanders: agriculture. As a consequence of rapid expansion over the last few decades in commodities such as wine, horticulture and dairy, New Zealand's two agricultural universities, Lincoln and Massey, have seen strong increases in student numbers since 2012. For instance, student numbers in the Bachelor of Agricultural Science degree at Lincoln have increased from 146 EFTs in 2012 to 223 EFTs in 2015 and new enrolments over the same period from 52 EFTS to 87 EFTS. Bachelor of Agriculture numbers have stayed about the same, averaging 80 EFTS over the same time frame.

Opportunities for graduates are many and varied with recent graduates finding employment in a range of industries including: family farms, agri-technology companies, agricultural support companies, crown research institutes, the dairy industry, red meat industry, arable research and many more. As in Australia, a recent survey of final year students suggested that most had found employment prior to graduation. Opportunities in the dairy industry are substantial with the industry estimating a shortage of at least 1000 trained staff per year.

At Lincoln University, the Bachelor of Agriculture and Bachelor of Agricultural Science have recently been reviewed and updated. Major changes include the introduction of University wide courses in problem solving that ensure graduates can work closely with commerce, marketing, tourism and environmental management students. New courses were introduced in precision agriculture and farm systems modelling to ensure all agriculture students are up to date with modern technologies.

Massey University offers a Bachelor of AgriScience with specialisations in Agriculture, Equine and Horticulture, along with a Bachelor of AgriCommerce and 4-year Bachelor of Science (Agriculture). For example, the AgriScience degree aims to produce graduates with the ability to integrate and apply science, technology and business principles to current and emerging issues in land-based and related sectors.

Both Lincoln and Massey University have developed research hubs with private agribusiness and crown research institutes with plans for further expansion. For example, the Lincoln Hub will include AgResearch, Landcare Research, Plant and Food Research and DairyNZ, resulting in one of the largest congregations of agricultural scientists in the southern hemisphere with over 900 scientists on site. This will create much greater capacity for supervising post-graduate students at both masters and PhD level.

V – Papua New Guinea (PNG)

Three of PNG's six universities offer specific degree-level agriculture, although the University of PNG has a School of Natural and Physical Sciences teaching Environmental Sciences and Geography, Earth Sciences and the Pacific Adventist University has a Bachelor of Science (Environmental Science). Total enrolments in agriculture and fisheries in 2010 were 751 (447 males and 304 females) whilst 176 graduated in that year. This represents about 6.4% of all Higher Education enrolments (Department of Education, 2011).

PNG University of Technology (Unitech) in Lae

The Department of Agriculture is regarded as being the leading provider of agricultural science education in PNG. It has about twelve academic staff across the major disciplines, 150-200 students enrolled in its four year degree program and a small number of postgraduate students. The Department was established in 1971 in Port Moresby at the University of Papua New Guinea but was moved in 1985 to Unitech in Lae because of the close proximity of 39 ha of developed land (Taraka Campus) for teaching, research and demonstration and the constraints of operating in Port Moresby. The farm encompasses facilities for livestock (poultry, pigs, goats), crops (both perennial and annual) and agricultural engineering (Unitech, 2013).

Papua New Guinea University of Natural Resources and Environment

This institution was formerly known as the University of Vudal (prior to that Vudal Agricultural College) and has incorporated campuses at Vudal, Popondetta, the Sepik and the National Fisheries College in Kavieng, New Ireland Province. Courses range from diplomas and undergraduate degrees in tropical agriculture and fisheries and marine resources to a graduate certificate and master's degree in management.

University of Goroka

This university is the third largest of the six universities in PNG and is by far the largest teacher education institution. The teacher's college was upgraded after the UPNG Council decided to unify teacher education programs in Goroka as a result of the National Education Reform and PNG's Higher Education Plan 1992. It has four schools and teaches agriculture as part of its School of Science. From its early days as a teacher's college, it trained agricultural teachers for high schools throughout PNG. In 2007, the university formerly incorporated an agricultural extension program with a four year degree for in-service extension officers by topping up two year agricultural diplomas after a minimum of two years field experience, conferring a Bachelor of Agriculture Extension (University of Goroka, 2010a,b).

Agricultural Vocational Education and Training (VET)

Specific agricultural VET courses appear to be only delivered in West New Britain where there were 16 enrolments in 2013 (Department of Education, 2014). Bonney *et al.* (2012) noted that given the importance of agriculture as a foundational step for development and PNG's reliance on agriculture for food security and employment, the lack of a widely available agricultural education program at the VET level appeared to be a significant constraint to development.

Status of resources and funding

A recent independent PNG and Australian Government report (Garnaut & Namaliu, 2010) found that PNG's Higher Education system faces major challenges, particularly in the areas of governance, funding mechanisms, performance quality, staff practices and a culture of research. For agriculture, land for the universities delivering agriculture was found to be constraining delivery quality and requires significant expansion or, in the case of Unitech at Lae, re-location away from urban expansion to enable full utilisation and exploit higher land prices that could subsidise operations. The report further recommended that constraints on the full use of the profits from commercial activities on these farms be removed.

Despite commitments from the subsequent bi-lateral Government planning (Department of Education, 2011), anecdotal evidence indicates that most institutions continue to suffer from a lack of funding, inadequate resources and poor maintenance.

Hence, the capability of the system to deliver the quality of education and training required to make a significant contribution to PNG's development may be severely constrained. Australia provides kina for kina support in key areas and overall provided about $65 million in 2014-2015 (Department of Foreign Affairs and Trade, 2015). Further, the Australian Overseas Development Assistance (ODA) program through the Department of Foreign Affairs and Trade (DFAT) as well as the New Zealand ODA program offer higher degree by research scholarships that are effective in training future scientists and research managers.

VI – University of the South Pacific (USP)

At the undergraduate level, the University of the South Pacific offers a Certificate in Agriculture, a Diploma in Agriculture and a Bachelor of Agriculture with a stream in Agribusiness and a second stream in Applied Science at its Alafura campus in Samoa. At the Laucala campus in Fiji, the Faculty of Business and Economics offer a Bachelor of Commerce (Agricultural Economics and Agribusiness). While the BAgr students have a good foundation in the agricultural sciences, these are seriously deficient in the BCom program. Conversely, for the BAgr program, instruction in macroeconomics and trade policy is notably absent. A recent review of the USP programs (Batt, 2014) recommended that the current offers be combined and revised to ensure that graduates have a sufficient understanding of both the applied agricultural sciences and the necessary business skills to effectively manage or to advise an agricultural enterprise.

Due to the size, isolation and the quasi-subsistence nature of agriculture across the Pacific Islands, there are very few job opportunities for agricultural graduates in the private sector. While most graduates have found work within the public sector, there has recently been a downturn in demand. To overcome the declining demand for graduates in the public sector, it has been proposed that a unit on entrepreneurship be introduced with the objective of encouraging graduates to become employers rather than employees. A more international, market-oriented, value chain perspective is desirable to facilitate exports and the growth of the agribusiness sector. However, neither course currently provides any instruction in postharvest technology or a basic food technology/food processing unit. Furthermore, graduates should have an appreciation of the need to promote and encourage more sustainable agriculture practices in response to climate change.

Across the twelve Pacific Island nations that USP currently services, while it may be possible to deliver some units in an on-line mode, the laboratory based units will continue to struggle to deliver the desired outcomes without the use of intensive residential periods of instruction. Yet, in spite of these difficulties, enrolment numbers at USP have been steadily increasing since 2011 (Table 3).

Table 3. Enrolment numbers at USP across all pre- and undergraduate agricultural programs from 2010 to 2014

	2010	2011	2012	2013	2014
Male	131	148	185	200	253
Female	91	102	122	149	203

VII – Conclusions

The Australasian region is located at the edge of Southeast Asia, a region undergoing transformational change as rapid population increases, urbanisation and the emergences of a more wealthy and discerning middle class. This has resulted in an increased awareness about issues such as food security and safety. The implications for the Australasian region as a provider of food and tertiary education are in the process of being recognised with some changes in public perception of agriculture and policies related to education evident. There are now early signs that this is actually translating into higher numbers of students enrolling in agricultural courses and degrees.

Agriculture remains an important part of the regional economies, including Australia and New Zealand. These two countries have the capacity and the natural resources to increase agricultural production and to satisfy some of the foreseeable increases in demand for skilled graduates. They also have the governance and institutional infrastructure that will allow them to act as educational hubs for the region. To capitalise on these opportunities will require communication, strategic partnerships, innovation and continous curriculum reform.

We now live in an age where on-line delivery, blended learning[1] and flipped classrooms[2] have become mainstream. As our external environment changes, so will our responses. For instance, many employers have highlighted the need for a generally better educated workforce, but not necessarily to degree level. In many industries there is a shortage of staff with practical, technical skills that are required to perform in modern and often high-tech workplaces. In addition to industry-specific skills, required competencies includes computer skills, core STEM skills, knowledge and appreciation of OHS standards and procedures, a better understanding of legal and financial issues, as well as marketing (Deloitte, 2014b). Many workplaces have now embraced the concept of life-long learning and are keen for their staff to upgrade their skills and qualifications regularly. This ranges from short, one-day courses to intensive and highly specialised programs. The Vocational Education and Training (VET) sector (Government, 2015a) needs to be better integrated with the curriculum of universities. Satisfying market demands in the pre-degree space might also create pathways for a future university education. We have now moved to a situation where the role of a university in providing tertiary education in agriculture has become multi-faceted demanding maximum flexibility from staff, curriculum developers, industry and students. Universities can raise to this challenge if they are willing to cooperate and show agility in the way they engage with each other and with their communities in order to address the issue of highest societal importance: how to feed a growing population sustainably, efficiently and effectively.

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[1] Units where a portion of the traditional face-to-face instruction is replaced by web-based online learning.

[2] A pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter.

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EARTH University Educational Model: A case study for agricultural educational models for the 21st Century

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Abstract. Education is the most powerful tool to transform a society, especially if we want to meet the needs of the 21st century. However, an education means more than going to school; it also includes what and how students learn. Education should be about empowering the student, encouraging questions and criticisms and providing students with opportunities to discover knowledge on his or her own. The student should be the center of the leaning process; professor should become a facilitator of the learning process in a participatory and experiential manner.

For the past 25 years the EARTH University –a private, non profit, international university located in Costa Rica– educational model has implemented this innovative methodology in accordance with its unique mission "to form ethical leaders for sustainable development and construct a prosperous and just society". The EARTH model focuses on four formative areas: scientific and technical knowledge, social and environmental awareness, ethics and values and entrepreneurship. Nearly 2,000 professionals from almost 30 countries in the Americas, the Caribbean, Africa, Asia and Europe have graduated from the EARTH model in this time. This article presents the EARTH case as a model for study.

Keywords. Educational Model – EARTH University – Experiential learning – Values – Entrepreneurship.

Le modèle éducationnel de l'Université EARTH : cas d'étude pour les modèles d'enseignement agricole pour le XXI^e^ siècle

Résumé. *L'enseignement est l'outil le plus puissant pour transformer une société, en particulier s'il s'agit de répondre aux besoins du XXIe siècle. Toutefois, l'éducation signifie bien davantage que le fait d'aller à l'école, car elle comprend également ce que les étudiants apprennent et comment ils l'apprennent. L'éducation devrait viser à rendre l'étudiant autonome, à encourager le questionnement et la critique et à apporter aux étudiants des opportunités pour découvrir le savoir par eux-mêmes. L'étudiant devrait se trouver au cœur du processus d'apprentissage et le professeur devenir un encadreur du processus d'apprentissage sur un mode participatif et expérientiel.*

Lors des 25 dernières années, dans le cadre de son modèle éducationnel, l'Université EARTH, une université privée, à but non lucratif, internationale, située au Costa Rica, a mis en place cette méthodologie novatrice conformément à son unique mission qui est de former des leaders éthiques pour un développement durable et pour la construction d'une société prospère et juste. Le modèle EARTH est axé sur quatre domaine de formation : savoir scientifique et technique, sensibilisation sociale et environnementale, éthique et valeurs et esprit d'entreprise. Sur cette période, près de 2 000 professionnels de presque 30 pays d'Amérique, des Caraïbes, d'Afrique, d'Asie et d'Europe ont obtenu leur diplôme selon le modèle EARTH. Cet article présente l'exemple de EARTH comme modèle d'étude.

Mots-clés. *Modèle éducationnel de l'Université EARTH – Apprentissage par l'expérience – Valeurs – Esprit d'entreprise.*

I – Introduction

An urgent transformation of existing higher education in agriculture programs is needed to lead about the way toward meeting the needs of agriculture in the 21st century. However, much of what passes for education today is not up to the task. Too many graduates are simply not prepared to meet the challenges they will face once they complete their studies. A new approach is essential for transformative education and providing young people with the awareness and skills needed by the emerging paradigm.

Several failures of the traditional agricultural educational model have come to light in recent years. For one, up until this point, the traditional method of agricultural education in many countries has been primarily theory-based and emphasized the role of the professor. Secondly, for several consecutive decades young peoples' interest in a career in agriculture was declining. Those who did pursue agriculture at the university level would very often work with the extension programs of the ministry of agriculture of his or her country. Accordingly, institutions of higher education in agriculture prepared students with a skill set to meet the demands of the sector they expected to serve. Nowadays, university graduates in agriculture expect to find work in the private sector and the need for enterprising individuals who will start their own projects is on the rise. This reality requires that graduates possess different skill sets than those of the past. Unfortunately, a gap exists between demand and supply as many universities have not evolved their educational models to account for the demands of today's labor market and innovative sector.

Another failure of current agricultural educational models lies in unequal access to a university education. Under the current model, student selection is based upon the results of an entrance exam. An inherent bias in this system favors students of a privileged academic background. Young men and women with poor educational backgrounds, often linked to a low socio-economic status, cannot compete with the test scores of their academically well-prepared peers and therefore miss out on the opportunity to pursue higher education. Unfortunately, this measurement does not factor in the potential for success or vocation of the student candidate. There many young hopefuls that dream of deepening their knowledge and experience of agriculture and who do not get the chance. Therefore, those individuals with the greatest access to education continue to benefit from it and those with the least access to it continue to be left out. The impact of this effect extends beyond the students alone. Taken into the broader context, this has repercussions for the entire community. In order to ensure greater equality in admissions to universities a serious revision of the selection processes must be undertaken.

There is clearly a need to transform the predominating agricultural educational model. Looking forward to the next 20 years, the need for this transformation will be all the more necessary. How can this be achieved?

II – The EARTH University model – Curricular pillars

For twenty-five years EARTH University–a private, not for profit, international university located in Costa Rica– has taken a unique approach to prepare leaders and agents of change in agriculture and the natural sciences for the 21st century.

The EARTH educational model takes an integrated and holistic approach to agricultural education. EARTH graduates are prepared to respond to society's need for a highly qualified professional in agriculture and natural resource management, with a solid base in technical and scientific knowledge and skills, as well as a developed social and environmental awareness and commitment, attitudes and values for effective leadership, and an entrepreneurial mentality. These competencies represent the four formative areas of EARTH's unique educational model. They are closely interrelated and constitute the structural pillars of the curriculum.

Scientific and technical knowledge: This area consists of the knowledge, abilities and skills that taken together give an EARTH graduate the technical competence required for the sustainable management of agriculture and natural resources. Development in this area is accomplished largely through active participation in the courses which comprise the formal plan of studies.

Social and environmental commitment and awareness: Developing students' sense of social and environmental responsibility and strengthening their capacity as leaders to promote positive change is an essential part of the educational experience at EARTH. This takes place both in the classroom and in the field, through the participation and involvement of students in experiential activities with communities and social development projects, in diverse co-curricular activities, in institutional programs and projects, and as volunteers in local and regional projects.

Ethics and values: This area involves the development of intrapersonal and interpersonal competencies that help students become effective leaders. Among these competencies are self-awareness, empathy, respect, tolerance, teamwork skills, effective communication, and becoming an autonomous, lifelong learner. This area also includes understanding and putting into practice values and attitudes that promote dialogue, peace, and understanding among people from differing backgrounds. This is accomplished in part by taking advantage of opportunities for dialogue, inside and outside the classroom, through participatory activities designed to inspire reflection, and the experience of living for four years in a multicultural environment. It is also accomplished through the formal plan of studies, in courses that include activities that deliberately encourage students to develop these abilities. Faculty and staff reinforce University values through role modeling. In this way, everyone at the institution contributes to the personal and professional development of the students.

Entrepreneurial mentality: This area involves helping students access the knowledge, skills and experience required for successfully managing enterprises as well as developing an entrepreneurial spirit. This is accomplished partially through the Entrepreneurial Projects course, a multi-year program that offers students the opportunity to conceive, develop and implement a business, assume risks and make responsible decisions in order to generate economically sound, socially and environmentally responsible products and services. Through this course, students develop the capacity to evaluate, plan, organize, administer, and take advantage of opportunities.

III – Experiential and Student-Centered Learning

Equally as important as *what* students learn is *how* they learn it. Transformative education is a participatory and experiential process. Students must take an active role in their own learning. A student-centered approach places the focus on *student* learning. Faculty are facilitators of discovery processes. This differs from the traditional university model in which the professor is the subject expert and he or she imparts knowledge to the student through lectures and assigned readings. Whereas classes in a traditional university setting take place principally in the classroom and are largely theoretical, in a transformative education context, learning takes place beyond the walls of the classroom or even the University itself.

At EARTH, learning is largely based on lived experience and practice and validated by theory. Courses bring students into contact with laboratory and field laboratory experiences, visits to farm and business operations, business management and operations, community development work, an internship experience, and research. EARTH's two campuses –one in the heart of the humid tropics and second campus in the dry tropics– offer students a unique and complementary educational opportunity. This format provides context from within which students can frame theoretical concepts.

Within the structure of the EARTH curriculum, students in their first year begin to develop an awareness of the complexity of systems and the role that people play in them. At the same time, emphasis is placed on the development of fundamental abilities and positive attitudes toward work. Later, in the second and third years of study, courses increasingly concentrate on the parts of the system and well-defined and specialized technical skills, but without losing sight of the whole. During their fourth year, the focus of the students' studies returns to a global vision, but emphasizes the role that they will play as future professionals.

By the time that EARTH students graduate they are well prepared for a career in much more than what has traditionally been thought of as agriculture. Curriculum reviews ensure that the experiences and content of the students' education remain relevant and anticipate the future needs of the field and society. Sustainability, clean energies, water and biodiversity management, environmental services, value added, and other related topics enter into the EARTH plan of studies. As a result, 94% of EARTH graduates report to be working in a field related to their study. Equipped with skills and knowledge of how to bring sustainable development to their communities, they return home eager to assume their role as leaders of change.

Other elements of the EARTH University educational model include elements of EARTH's activities. For example, EARTH has a commercial branch that provides a living example of a successful, sustainable business right on campus. From its inception, EARTH took an innovative approach to commercial banana production in a bold step to demonstrate to its students and the banana industry the compatibility of responsible production and profitability. EARTH began progressive programs to manage wastes produced by the banana operation. These include: production of banana fiber paper, recycling of the plastic used in the field, the development of an innovative water filtration system in the packing plant, and the transformation of organic waste into natural fertilizer. Apart from having become the norm in many commercial banana operations, these innovations have also been promoted by EARTH graduates around the world.

EARTH's research initiatives offer other examples of how the University puts into practice what it teaches. *Chagas* is a lethal disease that affects 16 million Latin Americans, especially the poor, each year. EARTH University and its partners –the National Institute of Parasitology (Argentina), the University of Santiago (Chile), the Catholic University of the North, Antofagasta (Chile), National University of Costa Rica, the National Institute of Biodiversity (Costa Rica), the University of the Republic of Uruguay, the Center of Biophysical Sciences and Engineering and the University of Alabama (USA), and NASA– created the ChagaSpace Project to find natural extracts from species of the humid tropics that block the enzymes of the parasite that provokes this illness, which can be found in many of the communities from which EARTH students come.

EARTH's students come from over forty countries in the Americas, the Caribbean, Africa, Asia, and Europe. The University's admission process is intensive and effective; EARTH faculty invest significant time to travel to remote communities around the globe to promote EARTH and later to conduct interviews with student candidates. Based on an evaluation of the vocation, leadership potential and attitudes and commitment to improving their community's quality of life during a personal and group interview, faculty select approximately 110 students to be admitted to the University each year. Admittance to EARTH is not limited by an entrance exam or the capacity to pay tuition. In fact, to ensure that EARTH gives the opportunity to pursue a higher education to those with least access to it, 70% of EARTH students receive full scholarships (20% receive partial scholarships, and only 10% are full-paying students). This intensive process yields good results; EARTH has a retention rate of 86%. EARTH students are motivated and through their experiences at the University they gain confidence and enthusiasm to take on projects back home.

IV – Conclusion

EARTH graduates are bringing sustainable development to their communities, transforming practices and changing minds, all while redefining what "agriculture" means. In 2015 EARTH University is celebrating 25 years of illuminating lives through its innovative, participatory, and experiential model. Today more than ever EARTH's educational model is seen as a vehicle for transforming higher education in agriculture. Universities have the distinct privilege and responsibility to prepare graduates to meet the challenges of the 21st century. To do so, the university must be prepared to take on the challenges of this young century. Is what universities are teaching, and perhaps more importantly, HOW they are teaching today preparing the leaders of tomorrow? Now is the time to reflect on this and determine if agricultural universities are sharing the tools that the future leaders in agriculture need to create a world in which peace, justice, and prosperity prevail for all.

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Agricultural Education in the 21st Century: North American perspective

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I – Background

The topic of this conference, Agricultural Education in the 21st Century, is certainly very timely. As the conference title states, we are indeed facing a global food security challenge as the world population continues to grow over the next several decades. Furthermore, agriculture has a significant environmental footprint which must be reduced as part of a global effort for long-term environmental sustainability.

The focus of much of the discussion on agricultural education has been on declining enrolment in traditional agricultural programs. This is understandable when one considers the challenge that the world faces in providing nutritional security to a rapidly growing global population. However, structural changes in our food system over the past half century have had a major impact on the demand for agricultural graduates. Chief among these has been the mechanization of agriculture and the associated increase in scale that have dramatically changed agriculture in developed countries so that those employed directly in agriculture now number as little as one tenth of those employed 50 years ago.

There are additional forces at work that are also influencing the choice of programs offered in agricultural faculties. The first is a recognition that environmental sustainability is threatened due to the demands on our ecosystem imposed by the rapidly increasing human population and, thus, there has been a significant growth in opportunities for graduates who have the technical skills to deal with a wide array of environmental issues, including reducing the environmental footprint of agriculture. Agricultural faculties are well placed to offer programs in this area due to the broad disciplinary base of agricultural faculties in both the natural and social sciences in areas relevant to the environment.

The food-nutrition-health continuum and the recognition of the importance of nutrition to maintaining a healthy population has spurred another area of growth in undergraduate and graduate education. As health care costs have escalated as a result of the epidemic of chronic diseases (obesity, diabetes, heart disease and cancer), there is a growing realization that the solution is to reduce the incidence of these chronic diseases in the first place by placing more emphasis on programs to support heathy living. Clearly, nutrition has a central role to play in human health and indeed there has been substantial growth in demand for dietitians and related health professionals.

Finally, the bioeconomy is emerging as an area of interest as governments encourage renewable sources of energy, as well as green chemistry, as an alternative to the wide array of products produced from the petrochemical sector. At the University of Alberta we recently engaged industry and other stakeholders to provide guidance on a proposed new bio-industrial program in this area. Although the program has not been officially launched due to budget constraints, the proposed program illustrates an emerging area of opportunity for graduates. The program also serves as an example of the evolution of agricultural faculties from the traditional BSc agriculture to include programs that encompass environmental and conservation sciences and those that link food, nutrition and health. This broadening of the traditional agricultural base has been in response to growing demand for graduates in these areas and it has helped boost enrolment in many North American agricultural faculties to record levels at a time when enrolment in traditional agriculture programs are static, or in decline.

As we focus on agricultural education in the 21st Century, we also need to be cognizant of the critical importance of soft skills for a successful career. A recent study[1] co-sponsored by the Association of Public and Land Grant Universities (APLU) is particularly enlightening in terms of the critical importance that employers place on these skills when recruiting employees. The results of this study merit particular attention at this conference as employers ranked soft skills higher than the technical skills that are the primary focus of curriculum development at universities. Clearly, soft skills are critical attributes in securing employment and for long-term career success in agriculture and life sciences.

Before discussing the University of Alberta bioindustrial program and the APLU study, I will provide some background that I hope will help promote discussion at this conference as we look to the future of agricultural education in the 21st Century. The key message is that undergraduate and graduate programs offered by agricultural faculties in North America have changed dramatically over the past half century. From a focus on production agriculture, programs have evolved to include the broad areas of environmental sciences, nutrition and health, and the bioeconomy as demand for graduates in these areas has often outstripped demand for traditional agriculture graduates. This trend is likely to continue in the future and thus we need to take a very broad view of agricultural education if we are to continue to be successful in attracting students who will go on to rewarding careers in helping solve some of the great global challenges confronting our planet.

II – Population explosion fueling global nutritional and environmental challenges

We are all aware of the explosion in the world population over the past 100 years. This dramatic growth is captured very nicely in the words of Dr Donald Shaver[2] when he states, *"Personally, I am astonished when I contemplate the simple fact that since I was born in 1920, the world's population has more than quadrupled and in less than four decades it will grow by half, to 9 billion"*. This dramatic increase in population is at the heart of the challenges that we face today in terms of food and nutritional security and environmental sustainability. To put things in perspective, consider that it took about one 100 thousand years from the origins of humans until 1825 for the world population to reach one billion people. A mere 100 hundred years later the world population had doubled to two billion, followed by an additional billion 33 years later bringing the population to three billion in 1960. Even more remarkable is that it only took between 12 and 15 years for each of the next four billion growth in world population – **thus four billion people were added to the world population between 1975 and 2011** when we reached a global population of 7 billion. In the face of this extraordinary growth in population, it is hardly surprising that we are

[1] Crawford, P., Lang, S., Fink, W., Dalton, R. & Fielitz, L. (2011). *Comparative Analysis of Soft Skills: What is Important for New Graduates?* Washington, DC: Association of Public and Land-grant Universities. Special thanks to Wendy Fink for permission to use the study results and for providing the PowerPoint presentation illustrating the study.
[2] The Gene Scene, Summer 2012.

being challenged as never before in terms of nutritional security and environmentally sustainability. Such massive growth has placed a huge burden on the planet that we call Earth which now faces the additional challenges and uncertainty associated with global warming.

III – Agriculture – the great success story of the 20th Century

Although we are naturally concerned that three quarters of a billion people go hungry every day, we often overlook the incredible success story that has allowed us to produce enough food to feed 7 billion people. When the world population reached 3 billion in 1960 most commentators did not believe that the world could produce enough food to feed 5 billion, let alone 7 billion. When you consider the amount of food wastage and the unequal distribution of the world's wealth, the problem is not that we do not produce enough food but rather that the food produced does not reach all the world's population. In the midst of the nutritional and environmental challenges that we face today, we should take pride in the great agricultural success story of the 20^{th} century, namely the fact that we were able to ramp up agricultural output in such a dramatic fashion to feed a global population that increased from 3 billion in 1960 to 7 billion in 2011. Consider also that the food to feed the first 2 billion people came almost entirely from increasing the agricultural land area whereas most of the increased production over the past half century has come from increased productivity brought about by technology and increased fossil fuel inputs.

IV – The imperative to reduce the environmental footprint of agriculture

As we look to the future and the expected growth in population to 9 billion in the coming decades, there is another reality that we need to face, that in addition to producing more food, we need to do so with a much smaller environmental footprint. Reducing the environmental footprint of agriculture will indeed be a huge challenges in the decades ahead. This is especially true when you consider that growing affluence in developing countries comes with increased demand for animal protein and an associated higher environmental footprint. Consider also that the growth in world population will occur primarily in developing countries with China and India predicted to be home to fully one third of the world population. It is also projected that there will only be a handful of countries with the capacity to be major exporters of food. While exports will continue to make an important contribution to nutritional security, the reality is that the key to global food security is "local" food production in countries with high population density.

V – Agriculture as a solution provider

As discussed above, estimates on numbers of people who suffer from food insecurity only tell part of the story. As food security is generally synonymous with caloric self-sufficiency it does not account for those who suffer from some form of nutrient deficiency, estimated to be as much as one billion people. Paradoxically, we are also faced with a rapidly growing population – as many as one billion or more, who suffer from obesity and chronic diseases such as diabetes and heart disease that are threatening the sustainability of health care systems. The traditional approach of spending over 90% of health care dollars on treatment of disease is not sustainable. Clearly, the answer is to take measures to deal with the root causes of the chronic, and largely preventable, diseases that are consuming so much of our health care dollars. Nutrition is a key determinant of health and there are indications that governments are prepared to invest more in this area as one of the foundations of maintaining a healthy population. Many agriculture faculties have grasped this opportunity by expanding nutrition programs that offer graduates interesting and challenging careers as dietitians. These programs are very attractive to students as shown by the rapid growth in enrolment in nutrition programs. The expansion of agriculture to include the link to nutrition and health provides an opportunity to move the focus of agriculture from "food" security to "nutritional" security. The former is most frequently seen as relating to caloric self-sufficiency while the latter embodies the critical importance of nutritional status in the maintenance of health.

VI – Impact of technology and scale of farms on agricultural education programs

As we look to the future and consider the question of agricultural education needs in the 21st century, we also need to recognize that one size will not fit all as agriculture has evolved very differently in developed countries compared to developing countries. As stated in FAO's 2014 State of Agriculture[3], "The sheer diversity of family farms and the complexity of their livelihoods mean that one-size-fits-all recommendations are not appropriate"… "Each country and each region needs to find the solutions that best respond to family farmers' specific needs and the local context".

In 1930 32% of the Canadian population lived on farms. Today 2% of the Canadian population are directly involved in agriculture. Even more striking is the fact that in the US and Canada, 4% of farms produce 66% and 50%, respectively of the total farm gate value. Contrast this with India where over half the population is involved in agriculture. Clearly, these huge differences in scale will impact the demand for, and the skill sets required of, graduates in the 21st century. Paradoxically, FAO states that 500 million farms produce 80% of the world's food and it is indeed disturbing that a large proportion of those suffering from food and nutritional security are small farmers and agricultural workers.

VII – Evolution of agricultural education programs

As farms in North America have evolved to larger and more mechanized operations with fewer employment opportunities in agricultural production, higher education institutions have also evolved in tandem. One hundred years ago the focus of agricultural universities/faculties was on production agriculture and the degrees offered were primarily agriculture degrees. Over time this has evolved so that, today, most faculties have changed their name to include words like "environment", "natural resources" and "life" as part of the faculty name. Similarly, degree programs have evolved so that students pursuing agriculture degrees often constitute a relatively small proportion of total undergraduate and graduate enrolment.

Although each institution will differ somewhat in the actual programs being offered, there are some broad patterns that can be observed. The first is an expansion of the production agriculture base to include increased emphasis on food science and technology driven by an increased awareness of the importance of value-added and the associated career opportunities in areas such as food technology and food safety. At the same time that is a greater public awareness and student interest in the area of nutrition as it offers a growing number of attractive employment opportunities.

The third area of growth has been in the environmental area. Agricultural scientists are well placed from a discipline perspective to play a leading role in the broad area of environmental sustainability. This has been a key area of growth in terms of students and research and thus has played an important role in helping agricultural faculties maintain and grow student numbers in the face of declining interest in traditional agricultural sciences. For example, at the University of

[3] The State of Food and Agriculture. Food and Agriculture Organization of the United Nations, Rome 2014.

Alberta there has been a dramatic shift in programs offered over the first 100 years in the life of the faculty, with the major changes occurring over the past 25 years. Over the first 70 years of the faculty students were primary enrolled in the BSc Agriculture program. Today about one third of our students are enrolled in nutrition and the next most popular program is environmental and conservation sciences with agriculture a distant third.

The recent introduction of a new animal health program has also proven attractive to students who are interested in both production and companion animal health. Overall student numbers are at an all-time high even though entrance requirements have increased substantially over the past decade. Students in all fields secure well paid jobs on graduation, the vast majority in their disciplinary area of interest. Demand is particularly strong in the agronomy area and employers are having difficulty finding suitably qualified individuals due to declining enrolment in this area.

As we look to the educational needs of the 21st century we need to be sure that we are asking the right questions regarding demand for agricultural graduates in the 21st century. If there is a lesson to be learned from the 20th century, it is that there were massive changes in agricultural production systems. We should expect these changes to continue in the 21st century and with them there will be impacts on the educational programs needed to meet the changing career opportunities in this sector.

VIII – Case Study: Stakeholder engagement in the development of a new Bio industrial program

The Province of Alberta, Canada has a long history of conventional oil and gas development and it has also experienced major growth associated with oilsands development over the past couple of decades. Alberta has a large land mass that supports strong agriculture and forestry sectors that are well placed to provide renewable feedstock to support a growing bioeconomy industry. The Province also has a well-educated workforce and high quality universities and colleges that, together with the Provinces abundant natural resources, provide a strong foundation for the further diversification of the economy in the renewable area. The Alberta Biorefining Conversions Network (BCN) brought together 85 senior leaders from industry, government and academia “to discuss the current global bioindustry landscape, the projected bioeconomy workforce and existing bioindustrial education programs; and develop a path forward for program development and workforce creation in Alberta”[4]. The stakeholders at this workshop were asked to review current educational programs at universities and colleges, to identify gaps and make recommendations for future programming.

1. The Banff Workshop participants were asked to address the following questions

- What are the core competencies and skills that industry is looking for in High Quality Professionals (HQP) and skilled labor for the emerging bioeconomy?
- Current and forecasted local demand for a bioeconomy workforce?
- The bioindustrial landscape, in regards to workforce in other jurisdictions; and thus what is it projected to look like in Alberta.
- What institutions have programs dedicated to training HQP in the bioindustrial space? Have they been successful?

[4] Building Alberta’s Bio-Industrial Talent Pool. Proceedings from the Alberta Bioconversions Network (BCN) Workshops, Banff. March 2012 and October 2014.

- What are the short and long term forecasts for both education and industry requirements?
- What can we learn from existing examples of programming in this space?
- What are the steps and timelines around implementing new programming? Do these align with industry?
- Is there any alignment between bioindustrial skills required by industry and the current system?
- What are the best paths forward?

2. Bioindustry skills and competencies identified

When considering the key jobs in this sector developing towards 2020 the workshop identified many different types of skills, however it was decided to focus on the following High Quality Professionals (HQP's):

- Primary producers: agriculture, forestry & biomass farmers/crop managers
- Trades: electricians, plumbers, machinery, other
- Technologists (primarily) and technicians
- Research scientists
- Engineers

3. The skill sets identified for Technologists, Scientists and Engineers were as follows

Technologists:

- More multi-disciplinary technologies & instrumentation
- Some added economics/business, project management competency
- Support system for small and mid-sized enterprises (SME's)
- More responsibility for problem-solving so as to handle 'routine' challenges (whereas difficulties or exceptions to routine go to engineers to handle)
- Work in/lead cross-functional teams
- Potentially move in from other sectors and need "re-set"
- Rapid re-training & re-tooling mechanisms

Engineers:

- Need to understand more bio-processes, build this into 4-year B.Sc. programs
- Raw materials coming in, biomass handling & transport
- Plant-wide process knowledge: know petro/chemical AND bio-systems
- Adaptability, added knowledge in business, communications, economics
- Multi-disciplinary in thinking and experience/assignments

Scientists:

- "Green" chemistry, lifecycle analysis, water efficiency
- Reduced environmental impact

– High-value end of biomass opportunities

– Wide variety in Bioindustry – fermenting, virology, biotech

– Conventional Focus, expanded/applied to new areas, natural health products

– Again, multi-disciplinary, theoretical + practical application

– Post-grad - more 'fluid' specializations

4. Potential undergraduate degree programs

Hon BSc. Bio Resource Program – Integrated Business-Science Program

Hon BSc. Bio Industry Technology

Hon BSc. Food Science – Adapted towards BioIndustry

5. Example of generalist undergraduate Bio-Resources Degree overview

Core Program 1st & 2nd Year Basic Elements	**Minors/Majors** 3rd & 4th Year Specialization/Focus
• Statistics • Microbiology • Molecular biology • Genetics • Organic chemistry – extraction/purification • Chemical/biochemical conversions • Genetically modified organisms • Entomology	• Synthetic biology • Fermentation • Industrial microbiology • Life cycle analysis • Advanced materials science/handling • Capstone: systems thinking type • Processing/transformation of biomass • Biofuels
Options/Electives	
• Macro/micro Economics • Business/marketing • Strategic communications • International trade & regulatory environ • Ethics	• Non- Thesis M.Sc. – BioProcess Engineering?

6. Program design conclusions for generalist undergraduate degree

– This kind of program IS possible – and there is a strong desire to advance

– It might be an adaptation of an existing degree – i.e. a new "major"

– Could be a new cross-faculty "program"

– Clarify target audience, then build the "business case"

– Involve leaders from industry and government and other external partners

– Bring together resources from various faculties – joint programing, perhaps across 3 universities.

– Work on the program is currently on hold as the introduction of a new program could not be justified at a time of reduced government support for existing programs.

XI – Soft Skills: Results APLU survey of employers, alumni, faculty and graduates

Michigan State University conducted a cross-institutional survey, in collaboration with the Association of Public and Land Grant Universities (APLU) and the University Industry Consortium (UIC), to determine the views of employers, faculty, alumni and students regarding the role of soft skills for a successful transition to careers in agriculture, natural resources and related careers. The study asked the question, what soft skills are employers looking for in new graduates? The survey involved over 8,000 people across the US that included employers, faculty, alumni and students. An initial study was conducted to identify and cluster the soft skills into seven broad groups, namely, Experiences, Team Skills, Communication skills, Decision Making/Problem Solving Skills, Self-Management Skills and Professional Skills. Employers and Alumni were drawn from a broad cross section of economic sectors that included For Profit, Government, Non-profit/non-government, and Higher Education.

One of the key findings from the study was that employers and alumni ranked soft skills as number 1 whereas students and faculty ranked soft skills as number 2 and 3, respectively (see Fig. 1). Faculty and students ranked discipline knowledge as number 1 compared to rankings of 2 and 3 by alumni and employers, respectively. When it came to the relative importance of each of the seven soft skills all groups ranked communication as number 1 and decision making/problem solving skills as number 2. Over half the respondents believed that soft skills training should be a shared responsibility between universities and employers. Students ranked Experiences much higher (#3) than employers (#6) in terms of importance for successful entry to the work place.

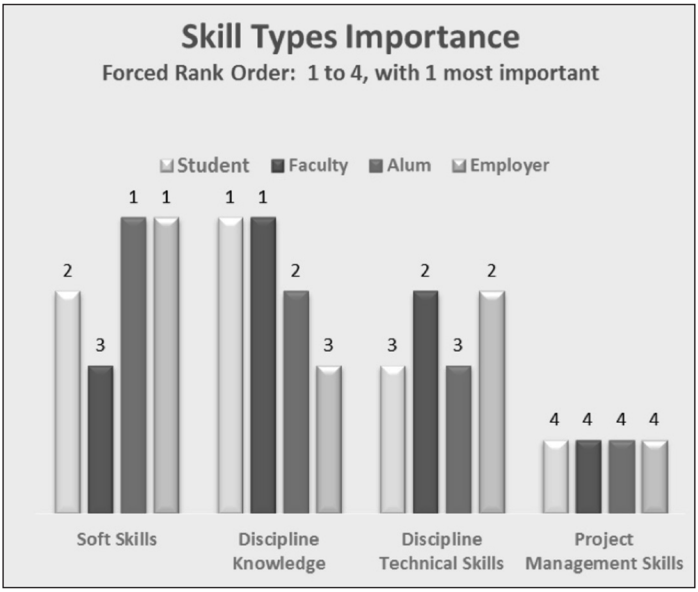

Fig. 1. Importance ranking of types of skills from students, faculty, alumni and employers.

The survey revealed some very clear differences among employers, faculty and students regarding the overall importance of soft skills, relative to disciplinary skills, as well as in their ranking of the relative importance of the soft skills. An important question for universities is how should these results inform curriculum development for the 21st Century?

Are current agricultural educational models suitable to meet global challenges? Case studies: Europe 1

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I – Introduction

2015 is the target year of the United Nations Millenium Development Goals and the launching of the Sustainable Development Goals (SDG). As two of the MDG were to eradicate hunger and to ensure environmental sustainability, SDG look for a world development based on-sustainability. World agriculture must face the challenge to feed an increasing world population, to produce a higher diet quality, to develop renewable sources of energy and changing weather patterns and, all that, respecting environment security.

All these challenges need a high number of graduates, with deep knowledge of Agriculture, Food Technology, Forestry, Environment, Biotechnology, Bioeconomy…, deep knowledge in Life Sciences. This is a challenge for universities of Agriculture and Life Sciences which have to face developing curricula in providing graduates with good competences and skills related to the needs of industry, government and society in the 21st century.

At the same time, during the last decade, the number of students in life sciences of Southern Europe universities, and especially in Spain, has been decreasing seriously. Where are all these students? Why aren't they interested in agricultural studies?

Simultaneously, new degrees related to environment, food technology, biotechnology or rural development have been offered by different higher education institutions. Often these universities lack an agricultural background. These education possibilities are actually more attractive for young people, who have interesting abilities and aptitudes and who look for an education related with life sciences. For the moment, these graduates have no problems of employment opportunities, often related with new needs of industry or society.

Some other reasons, related with the Spanish university system organisation, would probably also explain the present situation. The world and the technology changing rapidly, curricula need to be continuously modernized, adapted to new social challenges and to students' interests and abilities. The content and the title of the degrees would need as well to be renamed and, probably, the name of the faculties too. Escuelas de Ingeniería Agronómica and degrees in Agricultural o Agronomic Engineer are still present all around the country and have not been changed in Life Sciences Faculties or Life Sciences degrees as other European universities did 10-15 years ago.

Finally, in twenty years, the number of universities offering agronomic studies has been multiplied, responding to different social and political interests. A similar number of total agricultural students are distributed in many universities and faculties where research results may be excellent, but with a low number of agricultural students. Then, these faculties have often enlarged their education offer with degrees in food technology, forestry, environmental sciences or biotechnology.

This decreasing interest in agricultural studies tendency was observed also in Northern or Central European countries, some years before Spain. As statistics are actually showing an increasing new interest in agricultural studies in those countries, it is likely that this tendency arrives in Spain and that Spanish universities will be able again to recruit future graduates in Agriculture, as well as in other specialised branches of Life Sciences. A degree education related with agriculture, with a large overview, completed with a master degree in a specialisation in any field within life sciences or collaboration of professionals in different areas of life sciences would probably face agricultural challenges better in 21st century.

Current higher agricultural education in Poland – threats and challenges (Case studies: Europe 2)

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Abstract. The future role of agriculture in Europe will be not less important than it is at present and additionally we should be ready for uncertainty and threats (droughts, floods, social or political conflicts, crop failure but also crop surplus) regarding agro-food systems. Therefore farmers and advisers must be very well educated and prepared to the act in modern agricultural and food processing systems. The number of agriculture students and graduates has decreased recently, one of the reasons being the problem with jobs in agriculture sector and traditional programmes offered by Universities which do not fulfil the market demands and employers expectations. The modern agricultural universities and colleges should teach the biological bases of production and pay more attention to society needs and demands instead of typical technological knowledge which is very often offered by international firms and companies. Reform of higher agricultural education is absolutely necessary but it is clear that it will be successful only if it is supported by students and university staffs.

Keywords. Higher agricultural education – Internationalization – Number of students – Labour market demands.

État des lieux des études secondaires en agronomie en Pologne – Menaces et défis

Résumé. *Il apparaît que le rôle futur de l'agriculture en Europe ne sera pas moins important qu'il ne l'est aujourd'hui. En plus, nous devrions être préparés à faire face à certaines menaces (sécheresses, inondations, conflits politiques et sociaux, mauvaises récoltes et surplus de production) sur les systèmes agro-alimentaires. Ainsi les futurs agriculteurs et conseillers devront être bien préparés et formés aux techniques agricoles et alimentaires modernes. Le nombre d'étudiants et de diplômés en agriculture a récemment diminué, l'une des explications de cette baisse est un problème d'emploi dans le secteur agricole mais aussi l'inadéquation des programmes traditionnels proposés par les universités aux besoins du marché et attentes des employeurs. Les lycées et universités agricoles modernes devraient enseigner les bases de la biologie en production et davantage porter attention aux besoins de la société au lieu d'insister sur les compétences technologiques qui sont déjà souvent enseignées dans les entreprises internationales. La réforme des études secondaires dans le secteur agricole est indispensable mais il est évident qu'elle ne sera un succès que si elle s'accompagne du soutien des étudiants et de l'équipes pédagogiques des universités.*

Mots-clés. *Études secondaires agronomiques – Internationalisation – Nombre d'étudiants – Attentes du marché du travail.*

I – Introduction

According to the FAO statistics, the number of people around the world suffering from malnutrition and hunger in 2012 amounted to 870 million, which means 13 of total human population on the world. In the EU, almost 43 million people are threatened by malnutrition and 17% of Europeans are not able to fulfill the basic life requirements (http://epp.eurostat.ec).The population in EU at the beginning 2013 was about 505.7 million and it is predicted that until 2035 it will increase to 525 million. Together with the increase of population there will be increase of food demand, particularly for meat and some animal products. The expertise have prepared by World Bank suggested that global demand for food will increase by 50% and for meat and meat preparations by 85% (Evans, 2009). Increasing demand for meat could be risky because it is necessary to use 20 tones of feeds and fodder per each tone of meat. The feeds are mostly based on cereals and we have to remember that agricultural soils resources in Europe are rather limited (25 years of Polish Agriculture, 2014).

The global increase for food is a great challenge for the EU, where there is a large surplus of food production but on the other hand it is necessary to take into consideration the global situation and food security in the worldwide scale and react consequently. So the protection of food production in Europe is as important as the improvement of ability of agricultural productivity and competitiveness. European agriculture not only supplies the demand for food but also meet consumer's expectations for food quality, and guarantees an environmentally friendly way of producing food and the level of security which would be prone to global climatic and social changes which are predicted to occur in Europe in the nearest future. We should be also ready for some threats (droughts, floods, social or political conflicts, crop failure but also crop surplus), so it seems the future role of agriculture in Europe will be not less important than at present and farmers and advisers must be very well educated and prepared to the activity in modern agricultural production and processing of agricultural goods. From the theoretical point of view it is an excellent chance for higher agricultural education in Europe (Maquire and Atchoarena, 2003), but agricultural science and education are in deep crisis now and agriculture (in classic meaning as farming or agronomy) it is not attractive for students, is not fashionable enough (Podlaski, 2009) and does not always offer good jobs and satisfactory salaries for graduates. It should be also underlined that after the rapid increase of student population in European Union (in the years 1998-2000 the number of students increased by 25% and achieved 18.7 million) we observe now a decrease in the number of students caused by demographic crisis which hit many European countries. It is predicted that by 2030 in Poland the total number of students will decrease by 30% (Podlaski, 2011).

II – Changes in the higher agricultural education in the world

According to the report of The World Bank (World Bank, 2002) and Podlaski (2009) "the golden age" of higher agricultural education and investment into agribusiness was the time of Green Revolution and just afterwards. In the USA it happened in the seventies of last century. In that time popularity of agriculture was extremely high, also the total financial inputs for agricultural research were very good and what is important, public sector was interested in investment in agricultural production and education. Those large investments led to the increase of intensification and efficiency of agricultural research; an increase of agricultural production was observed and very soon surplus of food production appeared in developing countries. It was also the time of illusion that the growth of the role and importance of agriculture will a long life phenomena.

In the seventies in American universities teaching programs concentrated mainly on technological processes connected with the crop production and animal husbandry. Higher agricultural education succeed and as a result many very good agricultural specialists were educated, but they prepared mainly for applying the modern technology in agricultural production (Podlaski, 2009). The agricultural intensification caused the increase of problems with environmental protection, the over-utilization of nature resources and energy, etc. Questions about the limit of food production, food security, traceability or sustainable rural development became to be the main problem of modern civilization. As a result the best American Universities started to drift from traditional agricultural education into education based on life sciences (Podlaski 2009; Maquire and Atchoarena, 2003; Kukiel *et al.*, 1996). At that time European Common Agricultural Policy was changed, and development of rural areas started to be more important than agricultural production (Koucky *et al.*, 2005; Podlaski, 2009).

The Universities tried to adapt to the new situation but often instead introducing new teaching programs they started their activity from changing the name of universities and faculties as it happened for example in Wageningen (The Netherlands),Copenhagen (Denmark) and in some German Universities where the name “agricultural” removed. That fact appeared also in Poland when from 9 former agricultural universities only one still has the name “agricultural” (in Krakow), the rest of them has changed the official name from ”agricultural university”' to ”university of life sciences”. The lack of popularity of agricultural studies is a result of a notion that at present moment it is very difficult to find a good job having agricultural education. According to OECD (Education at Glance, 2007) and Podlaski (2009) employment in EU agriculture decreased by 2 million (from about 10 million employed in 2007). Reduction of employment in service and food processing sectors has been also noticed (Podlaski, 2011). Despite the global increase of students, the number of students in agricultural or similar fields of education in the EU decreases rapidly. The number of all students in EU increased in years 1998-2006 to 19 million (about 25% of all human population in EU), but among all graduates the ones who studied economics, sociology or law dominated (38%). Also medicine, engineering and humanistic studies were very popular (14-12%). Agricultural and life sciences universities were chosen only by few percent of students. This is confirmed in the last statistical studies (Education at a Glance, 2014, OECD Indicators) (Table 1).

Table 1. Distribution of tertiary new entrants by field of education (%)

Field of education	OECD average	EU average	Poland
Humanities, arts and education	20	20	19
Health and welfare	13	14	9
Social sciences, business and law	31	32	32
Services	5	5	10
Engineering and construction	15	15	18
Science	10	11	10
Agriculture	2	2	2
Not known	4	1	–

Source: Education at a Glance 2014, OECD indicators.

Policy of EU promotes and fosters the education in science (engineering, math and physics) because of the role of those field of studies in innovative economy. From OECD data (Education at a Glance, 2014) it is not clear however if this activity brings the expected results, as in OECD countries as well as in Poland, humanities and social studies are very popular whereas only 1-2% of young people are interested in agriculture. This is probably connected with the common opinion in Europe that it is not easy to find a good job after accomplishing agricultural education.

Universities try to react to that situation and in many countries, the names of present field of studies are being changed, and new specializations are established. They are given new names which are supposed to be attractive for young generation and should encourage them to decide to study although quite often, what the students are really offered, are the same programs and traditional teaching methods which were the core of the given university syllabus as many professors and lecturers are not interested in radical changes. Polish Evaluation Commission tries to evaluate the new fields of studies and often does not approve setting them up usually because of lack of good scientific staff or research and teaching equipment and facilities but on the other hand some large universities have the freedom and autonomy and many new, strange fields of studies have been established recently (e.g. plant medicine, hippology and horse riding, zoological parks and pet animals, applied animal psychology, space security etc.). In Poland during the last 5 years 47 new directions of field studies have been opened by the old agricultural universities and total number of those directions extended to 400. Similar situation is observed in many former higher agricultural schools in Europe, particularly in Central East part of Europe. Certainly the reform of higher agricultural education is absolutely necessary but on the base of Americans experiences it is clear that the reform will be successful only if it is supported by students and university staff (European Commission, 2008; Maquire and Atchoarena, 2003; Podlaski, 2011).

III – Higher agricultural education in Poland

In Poland the number of students increased from 403 thousands in 1990 to 1,954 thousands in 2005. Since 2006 we have been witnessing slow decrease in these numbers. At present 438 higher schools, universities and colleges educate 1.5 million students but it is reported by GUS (Central Statistical Office of Poland) (2014) and by the World Bank (2004) the demographic trend is not optimistic and probably the number of candidates for studies will decrease in 2020 by 40% in relation to 2002. The largest group of students are university students (455 thousand – decrease by 7.8% in relation to 2012), students of polytechnics (331 thousand – decrease by 3.5%) (see Table 2). In 2013 the number of new entrants decreased by about 11% in comparison to the previous year (GUS, 2014). The good indicator of education is the enrolment ratio. It started from 12.9% in 1990 to 53.8% in 2010, and currently it is 49.2%.

Table 2. The number of students at different type of higher schools in Poland on the years 2000-2014 (in thousands of students)

Type of school	2000/01	2005/06	2010/11	2013/14	%
University	443	563	527	455	29.3
Polytechnics	318	320	318	331	21.2
Agricultural	86	108	80,5	76	4.9
Economy	370	408	278	200	12.0
Education	148	112	102	55	3.5
Medical	29,5	49	62	60	3.8
Sport	22	28	28	25	1.6
Arts	13	15	10	17	1.1
Military and marine	22	25	26	27	2.0
Others	124	304	387	322	20.6
Total	1.585	1.954	1.841	1.550	100

In Poland, as well as in the world, students of agricultural specialisations are not the ones most satisfied with their choice of study (Podlaski, 2011), the majority of graduates would have chosen a different education path mostly institutes of technology or university education (Podlaski, 2009). The rapid decrease of the number of students in the last few years constitutes a characteristic feature of Polish agricultural education. The higher agricultural education in Poland is carried out on 9 universities of life sciences and in some State Professional Higher Schools, a total of 75,000 students study at these schools, which means about 5% of total population of Polish students (Statistical Yearbook of the Republic of Poland, 2014). As it has been mentioned earlier, in 2013 the number of first year students decreased rapidly at all universities, being especially noticeable at the field of agricultural studies. Only 637 students were accepted at the faculty of Agriculture in 10 Polish agricultural universities which was a massive drop (by 83%) compared to 2003. Typical agricultural fields of study (agriculture, horticulture, fishery, animal science, forestry) are nowadays chosen only by 1.5% of candidates. The number of graduates of those fields compared to the total number of all graduates who have finished their studies in the years 2011 and 2012 is also very low (GUS, 2014). A slightly more interest is paid for veterinary, food processing and food security and first of all architecture of landscape and tourism and recreation. The crisis in the higher agricultural education is observed also in the post graduate and doctoral studies: those studies-have been chosen by only about 1% of all members of those studies. Among the many reasons of that situation, one of great importance is the program of studies which is very often very similar to teaching programs which were presented to Polish students many years ago (Podlaski, 2011; Jakość kształcenia [Quality of Education], 2007). The modern agricultural universities and colleges should teach the biological bases of production and pay more attention to society needs and demands instead of typical technological knowledge which is very often offered by international firms and companies. This is also connected with situation in research studies in agriculture. The strong development of private sector in agricultural research means that a lot of results useful for farmers which can be applied directly in practice came from non-public institutions like from international breeding, seed or fertilizers companies and progress and effectiveness of those research is much higher than in universities (Podlaski, 2011). Traditional agronomy has lost its importance in the world scale, but to produce food in sustainably way calls for the new generation of agronomists able to comply with new civilization demands (Magor, 2013). Polish higher education is in the phase of changing but progress depends not only on investment in agricultural research and education but first of all on changing the mentality of staff, students and farmers as well.

IV – Internationalization of agricultural higher education

One of the most important activities within the frame of international policy of higher education is the consolidation and unification of university functioning and free students movement. Although in the world scale the substantial increase of students studying outside their own country is observed (from 0.8 million in 1975 to more than 4.5 million in 2012 (Education at a Glance 2014), Polish students rather rarely use the possibility to study abroad. In 2012 only 2.4% of them went to study at foreign universities (the most often chosen countries included the UK (37.3%), Germany (21.5%), France (5.5%) and the USA (3.7%). Poland has been the member of the Socrates-Erasmus program since 1999 and of the program "The lifelong learning program" since 2007, but only 50,000 Polish students decided for to study abroad (Jankowska and Jankowski, 2008). The most popular field of studies is business and management (20%), social science (15.1%), engineering (13%) and foreign languages (12%) (Statistical Yearbook of the Republic of Poland, 2014). The agricultural and life sciences are not popular, only 2% of students who decide to go abroad are interested in those studies but on the other hand it should be underlined that 60% of all Polish students plan to go abroad after studies in Poland and look for new job perspectives there.

Those students who took part in Erasmus program confirm the advantages of foreign studies (more practical and theoretical knowledge, improvement of important skills, better access to international labs and libraries, much better perspective for attractive employment).The number of foreign students in Polish higher schools has also been increasing. In the 2013/2014 academic year their number amounted to 36,000 (2.3% of all students). Much worse situation is in the field of agricultural sciences: only 0.5% of all foreign students in Poland selected agricultural or life sciences studies. Half of them chose studying at SGGW –the oldest and the biggest agricultural university in Poland. Internalization of education in Poland is one of the weaknesses of Polish education and one of the main reasons of the bad evaluation of teaching quality in many Polish universities which is reported by Polish Accreditation Commission. There is no doubt that it is possible to increase the number of foreign students at Polish universities (also in agricultural and life science universities) but it can only be achieved if there are more lectures and classes run in English and at least some of the teaching programs are changed (Podlaski, 2009).

V – The expectations of labor market and society for agricultural and life sciences students and graduates

In the year 1989 political and economic system in Poland changed and later similar changes have been noticed in many Central and East European countries but the evolution of the system of higher agricultural education stopped at the level of the seventies (Podlaski, 2009). The aim of each step of education should be the maximization of employment chances for graduates. European labor market does not need many graduates educated in narrow specializations in crop science or animal science even if they are prepared very well in those fields. There is an increasing demand for people prepared to solve the global problems connected with the proper use of global nature resources, global climate warming, biodiversity, landscape planning and management, food security or environmental protection. Multifunctional development of rural areas demands for graduates who are able to help at the local scales, and we need the people who are very well prepared not only in agricultural technology but in law, economy, services, and health issues (Kukiel, 1996; Podlaski, 2008).

Surveys carried out in 2011 by the Institute of Development of Economy (2012) in Poland among more than 600 employers in Warsaw and Mazovia Province indicate that fields of education and teaching programs at our universities are completely unmatched to labor market needs and demands. Competences of graduates expected by employers are far from real qualification of Polish students. The majority of graduates are not able to solve the problems, work in teams, students have problems with analytic thinking and self-education and with interpersonal communication. In employers' opinion universities should change not only teaching programs but first of all methods of teaching and pay more attention to practical knowledge and skills The universities are very often driven by their own, with narrow aims as the level and qualifications of academic staff, the present infrastructure, the tradition, and do not focus on real labor market and its needs. The employers should also have more impact on higher agricultural education and work together with academic staff to improve the present model of education (Jakość kształcenia, 2007).

The food security and rural development and management are noticed as very important fields of education and start to play very special role on the labor market. Food security is one of the most compelling global challenges. The rapid growth of the world's population puts great pressure on critical resources such as water, energy and food. Food security will become an ever greater priority for the EU and the world as the global demand for food increases and the challenges of sustainable production and equitable distribution become increasingly acute. The system of food production and distribution must meet the challenge of ensuring food security while at the same time dealing with the current impact of climate change on agriculture and adapting agriculture to lessen its future environmental impact. Half the EU's land is farmed, so initiatives to decrease emissions, maintain biodiversity, preserve natural resources and conserve areas of ecological and scenic value are of significant and increasing importance (Special Eurobarometer, 2012).

VI – Conclusions and final remarks

The crisis in Higher Agricultural Education has been identified and debated in national and international settings but despite a plethora of exhortations and suggested solutions change has been slow. While Higher Agricultural Education has succeeded with education for production, agriculture, it has generally failed to make the curriculum and management adjustments needed to provide the education and services required by a changing agricultural sector and the transformation of the rural space. Higher agricultural education has a key role to play in ensuring that critical knowledge and skills are imparted to teachers and students; that other rural development actors appreciate the role of agriculture and sustainable natural resources management and the synergies involved in working together to build human resource capacity. Higher Agricultural

Education institutions have to act quickly to clarify their roles or missions, establish their legitimate place in the higher education system and make the organizational and administrative changes necessary to provide a meaningful contribution to both the professional and general audiences concerned with rural development (Maquire and Atchoarena, 2003).

Higher Agricultural Education In in Europe is undergoing a deep crisis, agriculture seems to be not very attractive and not fashionable enough for young generation. The number of students and graduates has decreased during last decade. One of the reasons is the common opinion that it is not easy to find a good job and attractive salary after agricultural or similar field of study. Universities tried to improve the situation, they open new study areas and they changed the names of faculties and fields of education but very often those ideas and efforts are not compatible with market demands and employer expectations. The internationalization of agricultural studies is not on the expected level neither, only a small percentage of the student population in Poland decides to go abroad but many young people are going to look for jobs and some experience in foreign countries. On the other hand various universities, also in Poland have developed many interesting programs and activities in the sphere of sustainable development. Universities through their research work can contribute to securing a safer and more sustainable future against recognized threats such as climate change and environmental threats. Graduates with background in renewable energy sources, food security, sustainable development or rural and landscape planning are able to find their way to agricultural enterprises of different sizes. However further collaboration between the various universities should be the next step of higher agricultural education development. The future guarantee of better, more effective education lies in multilateral cooperation between educational institutions and business so there is a constant flow of information and support between academia and industry.

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Session III
Addressing the needs and challenges for innovation in Agricultural curricula

Agricultural higher education in the 21st Century: Non-traditional educational models

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I – Introduction: The status of the agricultural economy and the challenge of human resources

According to IFAD (2012), "there are about half a billion small farms in the world, supporting around 2 billion people and [the] food production needs to be doubled by 2050 in developing countries to assure food security. GDP growth generated by agriculture is up to four times more effective in reducing poverty than growth generated by other sectors".

In spite of its critical role, the trend in the agriculture sector has been a decline in terms of its contribution to Gross Domestic Product (GDP). The biggest slump can be seen in South Asia, which pioneered the Green Revolution in the 60's. The sector's contribution of 34.7% during the 80's came down to 18.5% during mid-2000's and similar trends were visible in other regions (Khilji, 2012). Such a decline in the contribution to GDP has not been accompanied by a concomitant decline in the sector's workforce. The share of agricultural employment, though reduced, still stood at 48% in South Asia, 38.4% in East Asia and 64.7% in Sub-Saharan Africa during 2007 (ILO, 2008).

An economic sector which employs 35 to 65% of the workforce, but only contributes 12 to 19% of the GDP, raises key questions. Disguised unemployment, under employment, and low or nil productivity imply that the sector needs a serious reconsideration in terms of investment and human resource development without which issues such as poverty eradication cannot be addressed. However, the investment seems to be decreasing substantially and according to FAO: "Between 2001 and 2012, the average national share of government expenditures on agriculture, forestry and fishing (GEA) fell almost 30%, from 3% of total government expenditures to just over 2%" (FAO, 2015). While the major portion of the farm investment comes from the farmers, the investment on research and extension has been mostly from governments. Thus the agriculture sector is characterized by high dependency on the state in terms of employment, investment, and the need to increase the production and productivity. Education, particularly higher education in agriculture, has been one of the causes and effects of this paradox.

II – History of agricultural higher education in developing countries

The colonial system influenced the development of education in many developing countries. The traditional style of indigenous education was transformed into an institutionalized form which provided a link between primary, secondary and tertiary education through schools, colleges, training institutions and universities. The brick and mortar, didactic mode of education began during the 19th century in many developing countries as an important tool for economic growth and social development.

Many Asian and Latin American countries witnessed a growth in higher education in agriculture during the nineteenth and early twentieth centuries. In contrast, Africa had a late start. The shift from extraction-oriented industries to production-oriented economic strategies by the colonial powers in the early 20th century led to the establishment of educational programmes for imparting technical skills to the local populations. While countries like South Africa and North African countries like Algeria had university education before World War I, the rest of Africa had to wait until the 20's and 30's before higher education institutions were introduced.

Post-secondary education in agriculture began in Makerere University in Uganda as a certificate course in 1924 and it was not until the 1960's that the large scale development of agricultural higher education took place in Africa. Between the 1960's and 1980's, around 20 universities introduced faculties of agriculture and veterinary sciences every decade (Beintema *et al*., 1998).

III – Challenges in agricultural higher education

History, resource constraints, ideologies and polices have affected higher education particularly in Africa. Bloom *et al*. (2006, p. ii) point out that the development of tertiary education was neglected due to the belief of the international development community that primary and secondary education were more important for poverty reduction. Within tertiary education, agriculture had been relegated to a lower status. Agricultural research and extension cannot mature without appropriate human capital trained at a tertiary level, and such a process requires adequate investment. Public spending on agriculture as a share of agricultural GDP in many Sub-Saharan countries at 4% was significantly lower than that of the transforming economies in East and South Asia which spent 10% during the agricultural growth spurt in the 1980's. The New Economic Program for African Development (NEPAD) has advocated an increase in agricultural spending to 10% of the national budgets to strengthen Africa's agriculture sector (Staatz and Nango Dembélé, 2008).

Lower investments have affected the availability of skilled human capital in African agriculture. While lack of adequate data does not given an exact picture, the trend seems to be clear. There are only 42 researchers per one million persons economically active in agriculture in Africa which is hardly 2% of the scientist-farmer intensity in the developed world (Ayre and Callway, 2005). There seems to be a similar trend in agricultural extension. Studies in Africa show that in Ghana, only 12% of male-headed farm households and 2% of female-headed farm households have access to extension services (Curtis, 2013). The research-extension-farm linkage is weak due to inadequate financial and human resources. The downtrend in agricultural higher education has affected this linkage to a great extent. An analysis of the tertiary enrollment in some selected Sub-Saharan countries reflects this concern (Table 1).

The lower enrolment in agriculture and the declining share of agriculture in total enrollments are the outcome of several factors. The excessive dependence on public sector employment, limited opportunities in private sector employment and the substantial fee and opportunity costs deter many students from joining tertiary agricultural courses. The recent increase in the private sector involvement in agriculture has started influencing skilled workforce absorption. Quoting a government report, the National Academy of Agricultural Sciences (2014) in India, points out while the targeted training capacity by 2022 is 20 million, the present system can only absorb less than 2 million per annum. Singh (2013) in his presidential address in the National Agricultural Science Congress during 2013 points out that while India produced 24,000 agricultural studies graduates during 2010, the projected requirement is 54,000 by 2020 necessitating a two fold increase in institutional capacity. Affordable access is a key challenge.

The quality of education is another major concern. A study on the skills, strengths and weaknesses among agricultural graduates in Botswana, Lesotho and Zambia shows that there is a gap

Table 1. Tertiary education and share of agriculture in Sub-Saharan Africa

Country	Total enrollment in tertiary education			Total enrollment in agriculture/tertiary level			Share of agriculture in total enrolment %	Annual growth % in the share of agriculture in total tertiary enrolment††
	Year†	Number	Annual growth %	Year†	Number	Annual growth %		
Burkina Faso	1999-2007	33,459	30	2007	321	–	1	–
Ethiopia	1999-2007	210,456	38	1999-2007	17,884	33	8.5	-0.1
Ghana	2000-2007	140,017	22	2000-2004	3019	8	4.3	0
Kenya	2000-2004	102,798	4	2000-2001	6969	5	7.4	-0.1
Malawi	1999-2007	6,458	13	1999	490	–	15.4	–
Sierra Leone	2000-2002	9,041	17	2000-2001	1360	315	15.3	10.4
Tanzania	1999-2005	51,080	15	1999-2005	2417	15	4.7	-0.3
Uganda	1999-2004	88,360	24	1999-2004	1403	11	1.6	-0.1

– not available.

† Earliest and the latest year for which data are available.

†† Years are the same as for agricultural enrolment.

Source: AGRA (2013, p. 131) based on http://stats.uis.unesco.org

between the employer's expectations and the performance of the graduates (AGRA, 2013). Skills relating to markets, financial management, communication and leadership are deficient among these graduates indicating a 'serious disconnection between …the tertiary agricultural education and the needs of the industry' (AGRA, 2013, p. 131). A study analysing 3,439 organizations employing agricultural graduates in India, indicate a gap in skills of about 75% at the graduate level and 70% at the post-graduate level (Rama Rao *et al*., 2011). Sumarti (2010, p. 151) refers to a similar trend in Indonesia where 'the image of agriculture and agricultural higher educational institutions –is declining posing a serious threat to agricultural development'. While governments have been supporting in-service training to strengthen the quality of services, its impact on the performance of the agricultural graduates is yet to be fully realized.

Even though Asia had an earlier start in terms of the green revolution, it continues to face the challenge of insufficient human resources. In India, the public expenditure on research and development of US$0.40 per US$100 of agricultural GDP is low compared to BRIC countries like China and Brazil and much below the developed countries such as Japan and South Korea (Kumar and Sinha, 2014). With the exception of Bangladesh, a declining or stagnating trend in agricultural research intensity can be seen in countries like China, Sri Lanka, Vietnam, India, Pakistan, Indonesia, Philippines, Malaysia and Nepal (CAPSA, 2015). Similarly in extension, it has been estimated that there are around 60,000 extension agents in India with one extension agent supporting 5000 farmers whereas in China with 800,000 extension agents, one extension agent supports 625 farmers (IFPRI, 2010). The challenges in agricultural tertiary education are the causes and effects of lower research and extension intensity which in turn contribute to the relatively poor performance of the agricultural sector.

A twofold increase in quality agricultural education will require substantial financial resources. Globalization, structural adjustments and various economic crises have influenced many developing countries to review the role of subsidies in the economy reducing the investment in agricultural education. Recently, India allocated USD73 Million to establish 12 new Central Universities. According to Altbach and Jayaram (2009), "one large research-intensive new Chinese university costs around US$700 million to build and has a total annual budget of close to US$400 million). Altbach (2004) estimates that the cost of creating a world-class university would be around 500 million dollars. Given the cost of establishing campus-based institutions, very few countries will have the financial resources to set up new institutions to absorb the growing demand.

To sum up:

- Agriculture is vital for sustainable development.
- Public investment as well as private investment in agriculture can increase agricultural production and productivity and reduce poverty. At present there is inadequate investment in agriculture and even these investments are declining.
- The declining investments have affected the research-extension-farmer linkage with low research and extension capacity.
- Tertiary agricultural education has not been able to supply the numbers of skilled and knowledgeable workforce required to support agriculture, due to historical factors, economic challenges and financial constraints.
- The conventional didactic mode of education promoted by the university system is inadequate to meet the demands of human resources in agricultural sector.

Hence a paradigm shift is required in approaching tertiary agricultural education. What are the options?

IV – Non-traditional Educational Models

As governments and policy makers seek to expand access to education, reduce costs and improve standards, it is clear that alternative approaches are needed.

In the previous decade we have seen an unprecedented demand for higher education. In 2007, there were 150 million tertiary students globally, a 53% increase over 2000. The number increased to 165 million in 2012 with an estimate that this is expected to rise to 263 million in 2025 (Altbach, Reisberg and Rumbley, 2009). If the children who will reach enrolment age between now and 2025 are to be accommodated, four universities with a capacity of 30,000 will need to be built every single week.

In the current economic climate, traditional brick and mortar solutions will not be enough. Four developments emerged as a response to the growing demand for affordable quality education, which have significant relevance for agricultural institutions as well.

This rising demand for higher education gave rise to a new type of provider – the distance education institution. The success of the Open University UK captured the imagination of policy makers around the world but particularly in developing countries.

When the Open University UK was established in 1969, the notion of 'openness' was a significant innovation. Lord Crowther, the founding chancellor of the Open University of the UK's statement of openness in relation to people, places, methods and ideas forms the basis of throwing open the ivory towers of higher education (Perry, 1976).

Open universities were oriented towards the massification of higher education. Many open universities do not insist on entry qualifications, allow learners to accumulate credits at their own pace and convenience and are flexible enough to allow learners to choose the courses they wish to study towards their qualification.

The new ideology was that learning could take place without a teacher and self-instructional materials were developed to cater to the diverse needs of the learners. There was a greater use of radio and television to supplement print materials. The learner was seen as a consumer – which was a major shift in ethos.

In 1988, there were only 10 open universities in the Commonwealth – 3 in Canada and only one in Africa, that is the University of South Africa (UNISA). Twenty five years later, in 2012, the number of open universities in the Commonwealth has increased to 28.

Why are open universities so popular? One reason is lower costs. The annual cost per student at the Korean National Open University is $186 as compared to nearly $3000 for a campus student. Similarly the costs for STOU students are $226 compared to $876 in a campus university (Perraton, 2000).

A study by the National Knowledge Commission (NKC), India, shows that mega-universities, which achieve economies of scale, cost substantially less than campus institutions. Pakistan's Allama Iqbal Open University (AIOU) costs 22%; China 40%; India's Indira Gandhi National Open University (IGNOU) 35%, and the Open University UK (OU UK) 50% as compared to campus universities (NKC, 2004).

What of quality? In 2012, the Open University UK ranked first in student satisfaction. In addition the OU UK ranked fifth among the 100 universities surveyed by the Quality Assurance Agency (QAA) in the UK and was one rank higher than Oxford University.

In the developing world, India has developed a national policy for distance learning and has established 17 open universities which cater to 23% of all enrolments in higher education. Here is an example of a developing country using a non-traditional approach to provide access to education for millions of its young people.

The agricultural education sector has been slow to take advantage of open and distance learning as a means of increasing access, improving quality and cutting costs, however examples do exist. In India, the Yashwantrao Chavan Maharashtra Open University (YCMOU) started its School of Agricultural Sciences in 1993 and has continually maintained its certificate, diploma and bachelor degree programs in horticulture. The Indira Gandhi National Open University (IGNOU) launched its School of Agriculture in 2005 and offers certificate, diploma, as well as doctoral programs. Among land grant universities in the United States, the Soil and Water Science department of the University of Florida pioneered offering degree programs in distance mode during the last decade. A number of other land grant colleges now offer degree programs in agriculture by distance.

With increased access to technologies, there is an increasing trend towards online learning, especially in developed countries. In 2013, almost all public institutions in the United States were offering online courses. In the same year, over 33% of all US higher education students were taking at least one online course (Allen and Seaman, 2014). After North America, Asia has the highest growth rate with developing countries like Myanmar, Thailand and Malaysia leading the continent in eLearning (Ambient Insight Research, 2013). According to the Babson Survey more than 80% of students considered online learning outcomes comparable with face-to-face, with over a quarter considering them superior (Allen and Seaman, 2014).

The first web-based course appeared in 1995 in Canada, a technology-based innovation in open and distance learning. Online courses brought in innovations such as authoring tools, learning management systems, unlimited web resources and online self-tests, which introduced a greater scope for interactivity. With the rise of social media, there has been a global movement towards collaboration in the development and sharing of content, which is concurrent with the rise of Open Education Resources (OER). The fundamental principle is that any materials developed with public funds should be made available freely to others.

OER are educational materials which are free and freely available, are suitable not just for higher education but for all levels, including primary and secondary education. OER can be reused and repurposed to suit different needs and can be made available in any format, including print, audio, video, and digitally. A key difference between OER and other educational resources is that OER have an open license, allowing for adaptation and reuse without request to the copyright holder.

The Commonwealth of Learning (COL) convened the World OER Congress with UNESCO in 2012. The declaration resulting from this congress has led to greater awareness about OER and its wide scale adoption. Several advantages of OER are identified and described (Kanwar *et al*., 2010). Two are particularly significant here. One is the adoption of open licensing, which allows potentially massive numbers of users to derive a direct benefit in terms of unrestricted access and use of high quality learning materials. The open licensing of software, which is an older and similar practice, has led to the availability of key information services at zero or affordable costs (an example is Wikipedia, which shares both its content and software under an open licensing regime).

The emerging use of open textbooks in parts of North America has led to the availability of good quality textbooks that come at zero cost to students (https://openstaxcollege.org/books). In the US, under the Utah Open Textbooks project, an OER-based textbook can cost as little as $5, or if accessed online, can be entirely free (Wiley *et al*., 2012). In another study of open textbooks Robinson, *et al*. (2014) found that students who used open textbooks scored 0.65 points higher on end-of-year state standardized science tests than students using traditional textbooks. A similar study published in *American Economic Review: Papers and Proceedings* in 2015 revealed that US colleges are charging lower fees for online course materials, suggesting that online education is "bend[ing] the cost curve" in higher education (Deming *et al*., 2015).

At the same time, a reasonable quantity of good quality digital learning material has been published online without an open license, rendering them ineligible as OER. The National Agricultural Innovation Project (NAIP) in India for example has produced course materials for 475 undergraduate courses covering six core areas of agricultural science, equivalent to about 15000 hours of classroom instruction (*ICAR, 2015)*. While this large collection of resources is in a digital, shareable format, access to them is limited by network firewall, and only possible for users with authorised credentials. The Jing Pin Ke (www.jingpinke.com), National Top Level Courses project of the China Ministry of Education is another example where learning materials are being shared, but not in a format that would qualify them as OER. Jing Pin Ke's 259 undergraduate courses in Mandarin are open for browsing, but do not carry an explicit open license.

A substantial quantity of higher education materials in the agricultural sector are not published online at all. The question of open licensing comes later. There is only one known example of an Open University publishing agricultural learning materials online (www.agrilore.org). This is a collection of learning material presented as 506 learning objects, as opposed to full courses, on topics relating to horticulture for smallholder farmers. Even here, the licensing arrangement under which they are shared is unclear.

There is a clear need for strong advocacy in the use of OER in agriculture, for building capacity among faculty who can produce online learning materials, and for the use of open licensing in publishing them. This is a need that is common to developed, as well as developing countries. A major effort by 20 institutions in developed and developing countries to create graduate courses online and to publish learning materials as OER was proposed in 2008 but received no support (IFPRI, 2010). Efforts such as these must be renewed and pursued vigorously. Large scale national efforts such NAIP and Jing Pin Ke should be encouraged to publish learning materials online with a suitable open content license in order to facilitate the reuse of these high quality learning materials.

What implications does this have for pedagogy? Terry Anderson terms the focus on networks and collaboration as 'connectivism', which places emphasis on collaboration rather than competition. The learner's role becomes more significant here, as it shifts from that of a passive consumer to an active producer of content.

Related to this shift is a fourth major trend, which has emerged partially out of the growing use of free content and OER. This is the Massive Open Online Course (MOOC), a form of distance and online learning. Started at the University of Manitoba in 2008, MOOCs gained traction in the ivy league institutions of the United States and have resulted in major consortia of top universities on both sides of the Atlantic: Coursera, EdX and Udacity in the US, FutureLearn led by the OU UK, and many others around the world. 2012 was declared by the international media as the year of the MOOC.

One of the common motivations for adopting MOOCs in developing countries is the democratisation of access to higher education. The Malaysian Minister of Education has encouraged institutions to leverage new opportunities presented by MOOCs to democratize access to higher education (Nordin, 2015). The Indian government is also seeking to use MOOC platforms to reach segments of society which are difficult to reach via traditional means, including the working class and women (Saath and Vikas, 2014).

The Commonwealth of Learning (COL) offers *MOOCs for Development* (MOOC4D), which are specifically oriented toward learners with modest exposure to online learning practices. MOOC4D offerings make use of platforms and technologies that work in low bandwidth scenarios, and are compatible with offline learning activities that are not affected by network instability. In developing countries, MOOCs offer a new way of providing cost-effective, structured guidance and information around socially critical topics such as health, education and political governance, as well as others with similar social relevance. This is how MOOCs are relevant in the food and agriculture sector.

A survey of MOOCs catalogued on *MOOC List* (https://www.mooc-list.com/) that are currently being offered via platforms such as *Coursera* shows that MOOCs on agricultural topics constitute an insignificant fraction (less than six out of about 3600). There is a need for MOOCs to build awareness among farmers about essential practices that are sound, ecologically and economically. To understand the perception and views of leaders of agricultural education and research community, COL organised a brainstorming event with the National Academy of Agricultural Sciences (NAAS), India on the viability of MOOCs in agriculture. The overwhelming opinion was that MOOCs were viable in agricultural education and training (NAAS, India, 2014).

COL has offered two MOOCs covering students and faculty in agricultural universities as well as smallholder farmers who contribute to bulk of the food production in sub Saharan Africa and South Asia. The MOOC for gardeners in India was unique in many ways. A gardener or “mali” (in Hindi) is a semi-skilled farmer who normally owns little by way of land and water assets. This group of farmers contributes much to horticultural and floricultural production (Anderson and Dron, 2011). Since this group has practically no access to the Internet and is likely to be unfamiliar with online learning, COL’s partner, the Indian Institute of Technology-Kanpur (IITK), built a complete suite of MOOC technologies to enable access to learning materials using a basic, voice-only cell phone. The content of this MOOC comprised sets of audio clips on farming practices related to 22 select fruits, vegetables and flower crops. These practices covered all aspects of cultivation from sowing to harvest. The content team comprising four agricultural scientists reviewed available information, including the *Handbook of Horticulture* (ICAR, 2010) and the *Krishi Gyan Manjusha* (Uttar Pradesh, 2012) used at the national and provincial levels as official sources of horticultural information The total duration of all audio lessons was 2 hours and 13 seconds. Each topic related to a given crop had a set of audio clips, with each clip an average duration of 15 to 60 seconds. A key aspect of this course was the availability of a call center operated by the course team. The call center was functional from 9:00 am to 10:00 pm on all days of the course. Most calls were received after 5 pm. The course team provided callers with information on how to use the services, and how to appear for examination, in addition to providing solutions if service-related problems were being faced.

A comprehensive survey of learners showed that most were 25-29 years of age, and their education level was mostly limited to secondary school. The learners ranked the content as high quality and relevant. At least some of the practices taught were applied almost immediately in the field. Learners appreciated the conciseness of the lessons, the clarity of voice, and the weekly quizzes. A total of 1055 individuals signed up via their cell phones, and about 65% remained active throughout the course. A total of 296 learners were eligible to receive certificates of participation. COL has also offered a MOOC on ICT basics designed for an audience that is predominantly from the milieu of agricultural education and research institutions. A total of 1893 learners enrolled with about 1260 remaining active throughout the six-week course. A survey of these learners showed very high levels of satisfaction with the topics and content presented. There is a demand for more courses like this one. Through these offerings, COL has been able to demonstrate that MOOCs can effectively meet the learning requirements of diverse stakeholders in the food and agriculture sector.

MOOCs mark yet another shift in teaching and learning by putting greater responsibility on the learner to construct knowledge through peer to peer interactions, and by shifting from teaching a small class to a massive group around the world. Will MOOCs transform the teaching and learning process? A significant difference is the emergence of the flipped classroom as the standard practice. There is a greater emphasis on peer-to-peer learning. The use of learning analytics, a component of the MOOC platform, can help collect and analyse data about how learning is taking place. Because of this, predictive systems can be developed to identify potential dropouts and provide the necessary support to help them overcome their difficulties. It can also highlight those areas where many students struggle so that the tutors get the feedback to take remedial measures.

V – The way forward

Distance and online learning have grown and evolved considerably over the last fifty years, keeping pace with, and taking advantage of various technologies that continue to emerge. Distance and online learning has also opened up access to millions of learners and is today a viable option for addressing issues of access, cost, equity and quality. While higher education institutions have taken advantage of these trends, the agricultural sector needs to deploy these non-traditional educational models. Developments in technology will serve to leapfrog to emerging developments.

What are the emergent trends of the future? The NMC Horizon Report (Johnson *et al*., 2015) estimates that in the next two years, social media will be ubiquitous and there will be a convergence of online and hybrid learning. Over the next three to five years, the availability of huge masses of learner data will make it possible to analyse this for continuous improvement and better outcomes. Learners will become creators of their own learning processes.

While professional education such as engineering and medical education are rapidly adopting distance and blended learning, agricultural education institutions in developing countries have yet to optimise opportunities and models that technology is currently providing. Though a small number of universities have started distance learning in agriculture, protocols and standards for quality assurance are yet to emerge. Policies and programmes oriented towards ODL, OER and MOOCs have the scope to address the issues in agricultural education, if they are adopted to suit the conditions of the developing countries.

The following steps can be considered:

1. Agricultural universities can adopt ODL and online provision to expand access and cut costs. By becoming dual mode, campus based institutions can offer two streams of provision that provide flexible options to learners, who can study at their own pace, place or time. In this case, ODL can supplement and complement rather than replace existing institutions and models.
2. When making this transition, policy makers would need to take a holistic approach. Rather than introduce ODL as an add-on, there would be a need to review existing policies and systems to inte-

grate the approach for optimal efficiency and effectiveness. One key dimension would be capacity building of all levels of staff to take ownership of ODL and to contribute to its effective delivery.

3. ODL and online provision can contribute to the ongoing professional development of the agriculture community and institutional personnel as well as provide opportunities for lifelong learning in this critical sector.

4. Agricultural universities need to embrace openness in a systematic manner. This would include adopting and adapting OER as well as open access policies for sharing and collaborating on research locally and globally.

As the international community gets ready to adopt the Sustainable Development Goals this year, the agricultural education community will need to adopt non-traditional and innovative approaches for human resource development if Goal 2, which aims to "end hunger achieve food security and improved nutrition and promote sustainable agriculture" (UN, 2014) is to be achieved by 2030.

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Needs for inclusion of technology transfer skills in curricula[1]

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I – Introduction

In 2010 I began working at the UfM in Barcelona as the DSG in charge of the Higher Education and Research division.

As you know Israel is a small country, we are less than 8 million habitants; however, on NASDAQ, Israel is classified as number 2 after the USA. This year, we are number 3 after the USA and Canada, before all European countries. I believe it will be interesting for you to learn how Israel was able to achieve this and I would like to point out that I am not saying that this is the best way but at least I will be able to give you an indication about innovation and our practices. As for myself, I was an academic for many many years in university and one day a friend told me to look up the meaning of academic in the dictionary. It states: "theoretical or speculative without practical purpose or intention; having no practical meaning or usefulness"; so I moved to the UfM.

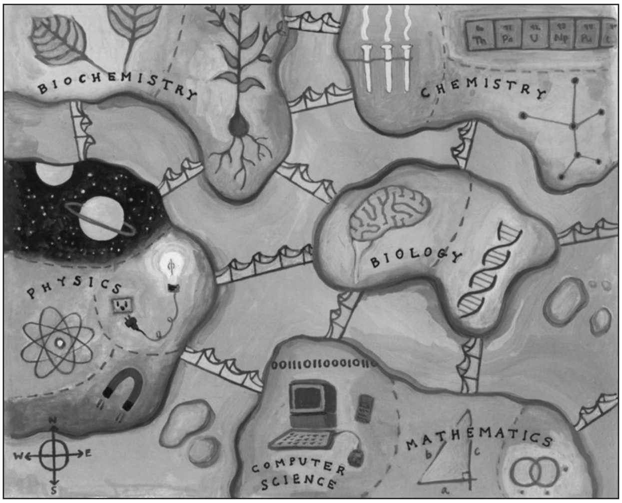

Fig. 1. Interdisciplinary Science.

[1] Illustrated transcription of the speech given by the author at the International Conference on "Agricultural Higher Education in the 21st Century. A global challenge in knowledge transfer to meet world demands for food security and sustainability" (Zaragoza, Spain, 15-17 June 2015, http://www.iamz.ciheam.org/educagri 2015/). The figures have been taken from the author's presentation at the Conference.

As you know science is becoming more and more complicated and today we often talk about interdisciplinary science. We combine biology and chemistry and it becomes biochemistry and the same with physics. So technology is more and more complicated.

I'd like to talk to you about the connection between academia and the industry because this link will bring us new inventions and new start-ups. University researchers come up with an idea, the research involved then leads to a publication. On one hand they receive public grants and contracts from companies on the other. The result of the research if it's applied research, are the patents. Companies apply research strategy and develop R&D through these patents. They have university scientists who support the industry in developing new inventions and often lead to new products. Universities benefit by receiving royalties or stock from these companies.

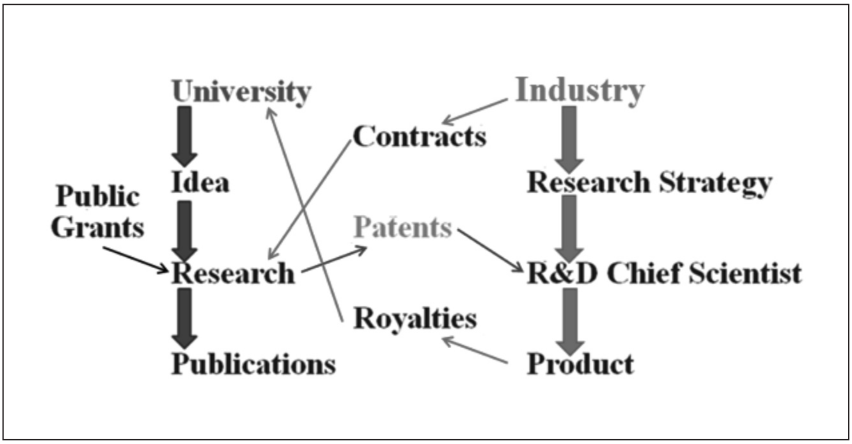

Fig. 2. Academia-Industry relationship.

If we look at the actual situation in most countries, we have university research institutes and laboratories. Companies are always searching for new inventions and products. The link between them is through what we call the Death Valley. It is a gap that we have to bridge between the unfinished product researched by the university and the product the company is looking to create. We most definitely need governmental support which is important and essential for the end results.

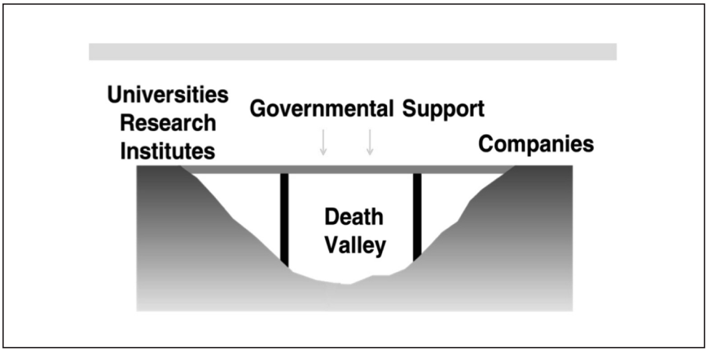

Fig. 3. Bridging the "Death Valley" gap between research community and companies.

Now, a lot of people talk about innovation and say how important it is to stimulate innovation, but innovation cannot be taught. We need to nurture it in the right atmosphere so that people will be stimulated to go towards innovation, and for this we need to give incentives to researchers in innovation. I will give you two examples of innovation in agriculture. There is a variety of tomatoes developed in Israel called ‘Daniela’. They are very famous because of their long shelf-life. They can survive outside of the refrigerator for up to 3 weeks. There is also another new development which is a plastic cover that is placed around the base of a tree. The wave like shape allows it to have a large surface area. It collects the dew and rain. Moreover water evaporates from the soil, rises to the top and then returns to the soil. It can save up to 50% in water.

Fig. 4. Left: the Tal-Ya Tray: A simple, scalable solution to some of the world’s biggest problems. Right: lemon trees planted simultaneously, after 3 years of identical care and drip irrigated; tree on left uses Tal-Ya Tray, tree on right does not.

Quoting Eleanor Roosevelt, she once said that *“the future belongs to those who believe in the beauty of their dreams”* and always an inventor has to be a dreamer.

So let’s now discuss technology transfer. Universities in Israel are semi-public universities and are therefore not allowed to do business directly with companies. They own companies and the companies deal with technology transfer and bring these findings to the marketplace. The company protects the university inventions and inventors and licenses them out through their team of professionals. It is very important that the inventor is protected by the university. Typical departments in technology transfer companies are; intellectual property dep., legal dep., business development dep., finance dep. etc.

I’ll give you an example of Harvard and as a top university in technology transfer. They disclose approximately 300 inventions a year, 133 new patents applications, 38 US patents issued, 37 licences to companies and 7 start-up companies are created. This is a typical successful university. Now let’s see an example of what universities can do with their inventions. The most successful one is from the Weizmann Institute in Israel which makes around 150 million dollars a year. Other examples are MIT: 76, Stanford University: 62, California University: 57 and the Hebrew University: 50.

This is not common in Europe. What I learned from visiting a university in Europe is that in Europe the tradition is that professors are less involved in invention and in the money aspect and there is a kind of reluctance to partake. I think first of all that this is not healthy and in my view is even immoral in a way because public universities are taking money from the tax-payer towards innovation and then when they have an invention, instead of receiving a substantial contribution towards their budget, they receive very little or nothing in return. Many good European universities don’t take advantages of their inventions and they give them away actually for free. As for the patents, in our system the researcher is always the inventor registered on the patent. However the university always owns the patent and never sells the patent but gives an exclusive license to the company, investor, venture capitalist etc. The intellectual property income is divided between the university and the researcher. If you remember I told you about the incentive you have to give to researchers – In our country we give the researcher 40% out of the royalties or stock because sometimes the start-ups don't have money so they give part of the stocks to the university and the researcher. This is a win-win scenario for everybody because the researcher doesn't have to hide his invention, it can be recognised by the university, the university receives a contribution from the company and the researcher is protected by the university and gets his/her share and an incentive to develop it. In Europe it is mainly being developed in the UK and Switzerland after the basic model in the USA.

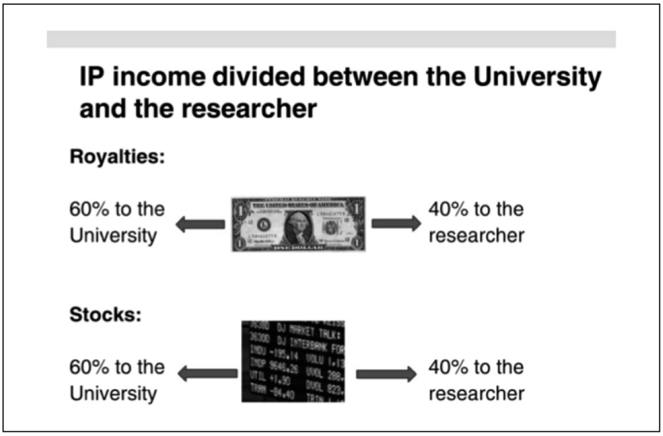

Fig. 5. Share of intellectual property generated incomes in Israel.

The anticipated time for a research application is between 2 and 7 years but you cannot expect to have a product after 2 years. The most successful product developed from the Weizmann Institute and made approx. 150 million for the university is a drug for multiple sclerosis makes over 3 billion each year in sales. It took almost 18 years to develop, so it takes a lot of time and a lot of patience is required.

When I was young I thought that inventions were the most exciting and the most important things. Over the years I have learned that marketing is not the most important tool but it can be just as important as the invention. Marketing products from universities can be problematic. First of all, marketing sometimes is not aggressive enough. There are difficulties in negotiating good contracts and many companies are exploiting universities. The contracts that are signed are weak in litigation. In many cases, companies do not believe that universities will sue them if problems arise.

On the other hand, to a scientist's advantage, he/she will receive a consultation bonus by the company. The patent is registered under the scientist's name. In many universities today patents account for the success and promotion of the professor. Occasionally there is scientific recognition, royalties or company stocks shares, and a strong chance of developing the product further.

I have to emphasize that we do not allow the researcher to be involved in the company itself, he/she can act as a consultant but never in a presidency or official duty. This may lead to a conflict of interest. As a whole, the 5 stages of a project are: excitement and euphoria, disenchantment, search for the guilty, punishment of the innocent and distinction for the uninvolved.

Recognition of traditional knowledge and innovative developments in agricultural higher education

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I – Introduction

The World population continues to grow at about 1.5% a year. The projected 7 billion for last year were reached and the UN statistics are estimating 8 billion for 2020. Nowadays contrary to the advanced agriculture and the extensive use of agrochemicals more than 40% of the crop productivity is lost due to the competition with pests and pathogens. Additional loss is attributed to the postharvest period. This could reach a very high figure in the developing countries due to the lack of advanced storage facilities. The challenge is here, because we have to double our food production on less per capita land, with less water, and under non adequate environmental conditions. Today one can realize in the northern, developed countries that the societies of the farmers are aging. Les as less young people are interested in to learn agronomy. This is an alarming issue in the OECD countries, where agricultural knowledge are advanced, but its transfer far behind and cannot attract the new generations. This raises concerns about communications, and a gap are existing in understanding between the agriculture and the society as a whole. In the developing world especially in the Mediterrean countries more classical agricultural educations are needed with an emphasis on the advanced techniques, too. By studying the development of the farming systems throughout the history one can realize that how big changes had happened. These rapid accumulations are exponentially grown along with the enormous discoveries in natural sciences. Those discoveries are completely reorganized and revolutionized the farming systems, and increased their productivities. This also had an impact on the agricultural higher education. All novel techniques have to be incorporated into the agricultural curricula, not forgetting teaching the classical agronomy and transfer a holistic approach in the education.

“De Agri Culture”, written by Cato the Elder 160 years before Christ, is the earliest existing work summarising the contemporary theory and practice of agriculture. A comparison of the agricultural knowledge recorded by this ancient philosopher over two thousand years ago with current agricultural practice presents a clear picture of how this time-honoured activity has developed. Writings on agricultural development reveal an exponential increase in the quantity of knowledge and experience accumulated over the centuries. The nomadic hunters and gatherers gradually became settlers as they turned to crop production and animal husbandry. Even today, however, there are still nomadic tribes who follow their livestock as their ancestors did, and gather plants to supplement their diet and cure their ills. Traditional knowledge in agriculture and medicine is still widely used both in China and South Africa. The enormous rise in the human population over the last hundred years has been accompanied by substantial developments in the efficiency of agriculture. To give just one example, maize breeders discovered that hybrids yielded far more than the varieties previously grown. Nowadays, compared to the 1.5 tonnes that can be produced with land races, up-to-date maize hybrids are capable of reaching yields of 10-12 tonnes, thus making a massive contribution to feeding the world population. The exploitation of the genetic potential of plants and livestock is still able to provide sufficient food for mankind, but we will soon reach the limits of sustainability if we fail to put new research results and innovations into practice. It is important to remember, however, that while the world population is rising, the amount of water and agricultural land available per capita is declining. As the earth can be regarded as a closed system, this will be decisive for the future.

Further developments in agriculture are indispensable and both the present and future generations will be faced with the task of optimising technologies to improve efficiency. This, however, will require up-to-date knowledge on agricultural science. Over the past centuries experts in crop production, horticulture, viniculture, forestry and game management and livestock breeding have summarised their knowledge in books that have been used as agricultural textbooks in secondary and higher education. As the volume of knowledge expanded, agricultural science has become increasingly specialised. Developments in science have had a decisive effect on both agricultural disciplines and farming practice. Figures 1 to 6 are representative of the technical development of farming practices during the last hundred years.

The 18th century was the age of physics and resulted in enormous technological progress in agriculture. The invention of the steam engine was the first step in the modernisation of soil cultivation, and the numerous technological innovations in the milling industry provided the framework for the establishment of the food processing industry. The age of chemistry came in the 19th century, when the use of chemicals in agriculture revolutionised plant nutrition. Justus von Liebig discovered not only which elements are of importance for plant nourishment but also the significance of the mutual ratios of these nutrients. He established the fact that each nutrient must be available in optimum quantities if the plant is to develop satisfactorily. Even when well supplied with most nutrients, if there is an insufficient amount of one, say calcium, in the soil, the plant will turn yellow and eventually die. To illustrate his hypothesis, Liebig used the example of an old barrel, the staves of which are rotted to different extents. Even if most of the staves are in good condition, the barrel can only be filled to the height of the most rotted stave. In the language of physiology, this is the limiting factor.

Fig. 1. Threshing in Hungary 1940.does not.

Fig. 2. Threshing in Hungary 1940.

The direct aim of manuring, or fertilisation, is to provide crops with nutrients, but indirectly it serves to increase the fertility of the soil. Information on how soil fertility can be maintained and improved can be gained by analysing cultivation systems. The insight gained into the importance of crop rotation crystallised in the elaboration of a new technology known as the Norfolk four-course system. The development of these new methods depended greatly on progress in social and economic conditions. An analysis of developments in farming systems reveals three distinct periods.

Fig. 3. Weed control 1956 in Hungary.

Fig. 4. Harvest in 2000.

Fig. 5. Global Positioning System directed seeding 2012.

Fig. 6. Small field plot threshing machine 2012.

The first, when slave labour was used, was characterised by a low standard of soil utilisation and agronomic knowledge was still purely empirical. During the second period, which lasted until the end of feudalism, there was a gradual development in the field of natural sciences. The third period began with the rise of capitalism, when rapid developments in the sciences had a great influence on both industry and agriculture. Developments in industry also had an intensive effect on agriculture. The farming systems in each of these periods were all of different standards and used different methods to maintain soil fertility. In the earliest systems the regeneration of soil fertility was basically left to natural processes, while today it is mostly accomplished through human intervention in the form of manuring, mineral fertilisation, irrigation, soil amelioration, etc. Agricultural literature distinguishes the following farming systems: ***1. fallow, pasture and forest rotation, 2. fallow, 3. crop rotation, 4. grassland, 5. free or monoculture farming system, including precision farming and 7.recently, the so called organic production.***

Around 35% of the crops produced worldwide are destroyed by pests. The need for efficient pest control and the elaboration of up-to-date crop production technologies requiring less live labour made it essential to use pesticides on a wide scale. Chemical pest control first involved inorganic salts (copper, mercury, arsenic) and natural active agents (nicotine, pyrethrum), but chlorinated hydrocarbons, produced from petroleum, soon appeared, followed by the organic phosphoric acid esters and carbamates originally designed for chemical warfare. Later, pharmaceutical companies specialised in the manufacture of pesticides. By the end of the 1990s around 700 chemical and biological compounds were utilised in crop protection. These products contain biologically active ingredients capable of killing weeds, insects or fungi, but if the technology is not strictly adhered to they may also destroy useful organisms, lead to the proliferation of certain pests or the development of resistance, and pollute the environment. The application of pesticides introduces toxic and persistent chemicals either directly into the soil, by surface distribution or ploughing in, or into both the soil and surface waters, via aerial spraying, and in many cases these compounds drift away from the target area (off-target effect), leach into rivers and lakes (run-off effect) or exert their effects on non-target organisms. The contradictions involved in the use of crop protection agents can be illustrated through the example of DDT. Paul Müller was awarded the Nobel Prize for proving the efficiency of DDT against insect pests. The introduction of this compound into crop protection in the 1940s during the Second World War solved numerous medical and food supply problems. Thanks to its use, malaria disappeared from Europe, it killed the lice that tormented both soldiers and civilians during the throes of the Second World War, and it helped to save the population of Europe from starvation. However, the success achieved with this insecticide caused both users and the chemical industry to become complacent and no efforts were made to develop other biologically active molecules as an alternative to DDT and other chlorinated hydrocarbons.

The 20th century wrote itself into history as the century of biology. The single page report by Watson and Crick in Nature (1953) on the structure of the hereditary material completely changed our thinking on heredity. The discovery not only proved that the two geniuses of the 19th century, Darwin and Mendel, had been right, but also formed the basis for a revolution in biology, which later led to breakthroughs in molecular biology. The first milestone in the biological revolution opened up enormous possibilities. After the key to the genetic code was found, it proved possible to determine which part of the hereditary material was responsible for certain traits, after which these were isolated and then transplanted into other living organisms. The development of the first transgenic organism by Paul Berg was soon followed by many others. The breaking of the genetic code, the identification and isolation of genes for individual traits and their incorporation into other organisms launched the science of genetic engineering. In 1983 two independent research teams, led by Mary Dell Chilton (North Carolina, USA) and Jeff Schell (Belgium) reported the development of the first transgenic plants, thus extending genetic engineering to plants. The success achieved in this field can be illustrated by the fact that in 1996 the first transgenic plants grown for commercial purposes were cultivated on only 1.6 million hectares, whereas today this area is over 184 million hectares (compared with the approx. 6 million hectares of cultivable land in Hungary). Following the prophetic warnings published by Rachel Carson in her book Silent Spring on the dangers of chemicals and herbicide resistance, and on the need for biological plant protection, the first transgenic plants were designed to have resistance to viruses, fungi and insects. Unfortunately, the social acceptance of these crops in Europe is based not on their usefulness and economic advantages, but on the demagogic repetition of presumed risks designed to mislead a population with no real knowledge of the science involved. The biological discoveries made in recent years have placed plant and animal breeding on a new basis and have put the favourable properties of microbes at the service of farmers and the food industry. Breeders can now use a wide variety of molecular techniques during the work of selection, including marker-assisted selection, and the plants produced in this way cannot be considered as genetically modified organisms in the classical sense of the word. It should be noted here that the whole issue has been over-politicised and has no basis in reality, since the system that has arisen due to the proliferation of regulations in the EU is only favourable for multinational companies, who alone have the capital required to apply for registration.

In the meantime new developments in agricultural technology also have enormous potential for innovation. The use of informatics has led to the establishment of geoinformation systems that allow growing areas to be accurately identified, including the crops grown on them, the amount of weed cover, the presence of epidemics, etc. The use of robots may also be part of the environment-friendly technology of the future. Nor should the rapid developments in the food industry be forgotten, where we turn a blind eye to the use of genetically modified (and completely risk-free) microbes, which now play a decisive role in European food processing, too.

The arguments outlined above make it quite clear what enormous developments have been made in agriculture and related fields of science and raise the question of what should be taught in the higher education system. As stated at the conference, genetics alone doubles the quantity of knowledge available to us every three years, and, if not to quite the same extent, this is also true of science in general, not to mention informatics, which is developing even more rapidly. It is becoming increasingly clear that the regional requirements of agricultural higher education should be given priority. Aims must be defined, and demands must be adjusted to the conditions available. Practice-oriented higher education is more effective than that based purely on theory. At undergraduate level practice-oriented courses satisfying regional requirements should be preferred, while in developed countries it would be worth basing agricultural higher education on efficient, up-to-date technologies.

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Needs and involvement of the public sector in higher education in emergent economies. The Moroccan case

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Abstract. This paper explores the involvement of the public sector in higher education. Empirical findings and field observations are presented using the Moroccan case. The main challenges are presented and discussed. Growing population demand for higher education, imperative financial burdens, weak private sector participation, and market forces are discussed. Drastic societal changes are creating new and complex tensions within public universities. Cultural-political-religious issues and values create new disruptive challenges for university managers and professors. Faculty promotion and stature are less based on their teaching skills and more on published research papers. Governance concerns and resistances to changes from students and professors within the higher education system are indicated. Ministries, university managers, professors, students and parents seem to be on different pathways. The pace of implementing changes is slow compared to the growing needs. In addition, the collapse of elementary and high school education systems presents the biggest future challenge for improving higher education.

Keywords. Morocco – Education reform – Public – Private – Dual system – Bilingual system – Growing demand – Financing – Politics – Governance.

Besoins et engagement du secteur public dans l'enseignement supérieur dans les économies émergentes. Le cas du Maroc

Résumé. *Cet article explore l'engagement du secteur public dans l'enseignement supérieur. Des résultats empiriques et des observations de terrain sont présentés en utilisant le cas du Maroc. Les principaux défis sont présentés et discutés. Sont examinés : la demande d'une population croissante en matière d'enseignement supérieur, la charge financière impérative, la faible participation du secteur privé, et les forces du marché. Les changements sociétaux drastiques créent de nouvelles tensions complexes chez les universités publiques. Les problématiques et les valeurs culturo-politico-religieuses entraînent de nouveaux défis perturbateurs pour les gestionnaires et les professeurs des universités. La promotion et l'envergure des facultés sont moins basées sur leurs compétences pour enseigner et davantage sur les articles de recherche publiés. Les préoccupations de gouvernance et les résistances aux changements provenant des étudiants et professeurs dans le système d'éducation supérieure sont indiquées. Les ministères, les gestionnaires des universités, les professeurs, les étudiants et les parents semblent avoir en vue des parcours différents. Le rythme de mise en place des changements est lent comparé aux besoins croissants. En outre, l'échec des systèmes d'enseignement élémentaire et secondaire constitue le plus grand défi futur en vue d'améliorer l'éducation supérieure.*

Mots-clés. *Maroc – Réforme éducative – Public – Privé – Système dual – Système bilingue – Demande croissante – Financement – Politique – Gouvernance.*

I – Introduction

Higher education in Morocco is mainly provided by open access public universities that are hosting 89% of enrolled students, followed by public specialized engineering and business institutes with 5% enrolled students. The private higher education system is recent and enrolls only 6% of the total number of higher education students (Ministère de l'Education Nationale and Ministère de l'Enseignement Supérieur, 2015; Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015). We will characterize the education system, outline its weaknesses and strengths and present its main challenges.

Many top-down government attempts to reform the educational system have had limited success. A major breakthrough was achieved when all partners (government, political parties, unions, civil society representatives…) agreed to sign a general commitment called "La Charte Nationale de l' Education". Morocco has established the Higher Council for Education and Scientific Research "Conseil Supérieur de l'Education, de la Formation, et de la Recherche Scientifique". It provides a platform for wide-ranging consultation and exchange of views among educational social partners. The council serves as an active observatory system to monitor and assess the entire national educational system and has the mandate to suggest necessary reforms to the government. A new reform was introduced in 2000 that used many principles of the Bologna EU reform to harmonize the higher education system and introduce needed changes.

Based on Moroccan and IAV Hassan II experiences, the main hurdles that are causing delays and unnecessary obstacles to achieve needed changes are highlighted below.

II – A dual and unbalanced education system

As in many francophone African countries, the Moroccan higher education system includes a new private system and a strong dual public system. The private higher education system is recent and enrolls only 6% of the total number of students (Ministère de l'Education Nationale and Ministère de l'Enseignement Supérieur, 2015; Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015). The public system includes two distinct components.

The first component of the public higher education system involves a wide range of universities covering mainly the fields of literature, social sciences, law, biology, mathematics, chemistry and physics fields. The majority (89%) of students are enrolled in these open access universities (Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015). Students are admitted with no special requirements, providing they completed high school and received their high school final diploma called "Bacalaureat". This system is completely open access and free of charge. It is governed and managed by the Ministry of Higher Education (see Fig. 1).

The second component of the public higher education system includes specialized engineering and business institutes covering mainly technical fields such as civil engineering, architecture, agriculture, management and medicine (5% of the total number of students). Access to these specialized institutes is regulated and very competitive. For the engineering and business institutes, the number of applicants exceeds the available seats. For instance, IAV Hassan II administrative records show that the institute receives more than 13,000 applicants each year for 450 available seats. In fact, specialized institutes receive and train a small number of students compared to open universities. However, they offer higher quality training and their graduates have easy access to the job market. These specialized institutes are under the authority and governance of technical Ministries (Ministry of Health oversees medical universities, Ministry of Agriculture oversees agronomy and veterinary institutes, Ministry of Public Works oversees civil engineering institutes, etc.). For these institutes, the Ministry of Higher Education issues regulations and accredits specialized curricula but has no management mandate over this high education sub-system.

These two components of the public higher education system are entirely free of charge. The government provides investment budgets, as well as those to cover university-operating costs. In addition, many students receive scholarships to cover their living expenses.

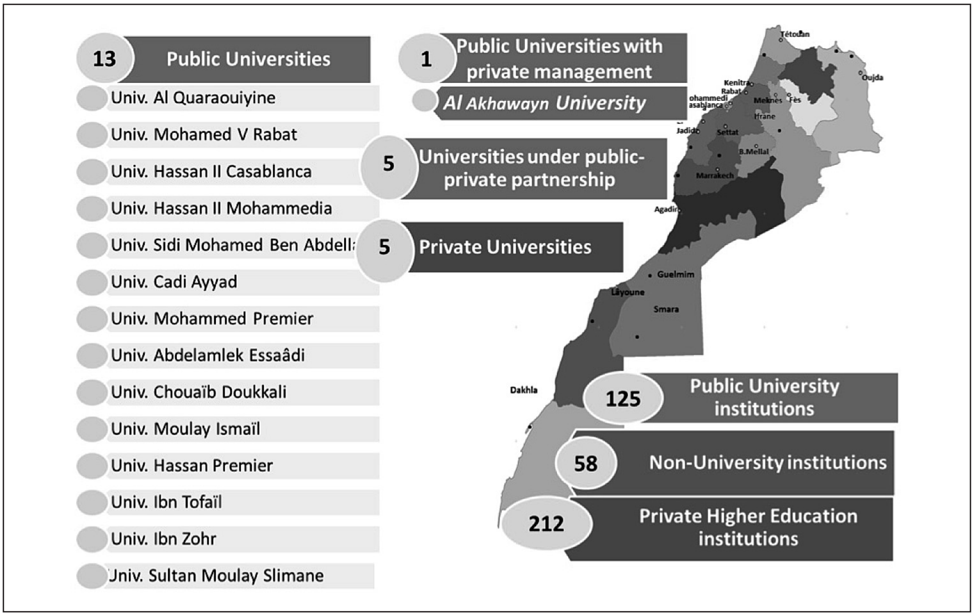

Fig. 1. Moroccan Higher Education System.

Adapted from Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015.

III – Fast growing demand, equity, quality and financial burden

The system is facing a rapid growing population demand. The number of registered students in the public higher education system increased drastically from 306,000 in 2010 to 471,000 in 2013 and reached 615,000 in 2015 in the Open University system. These trends will continue in the coming years (Fig. 2).

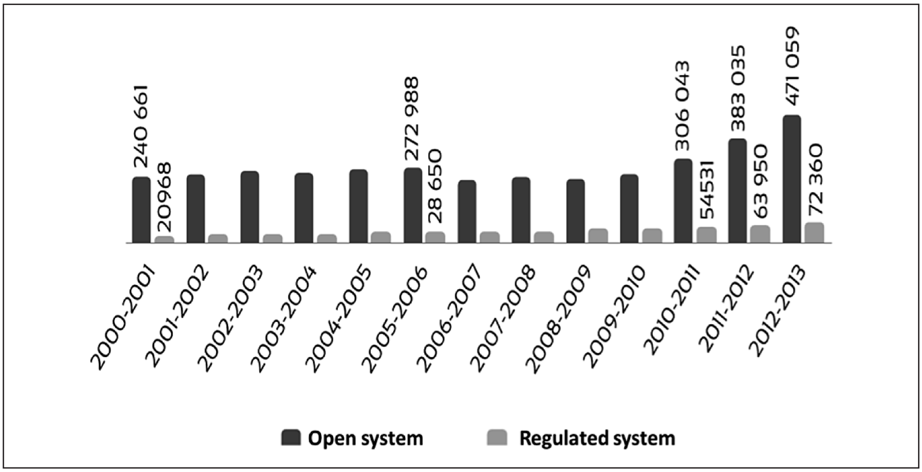

Fig. 2. Number of university-enrolled students Enrolled in 2015 = 615,000 students.

Source: Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015.

In spite of these high figures, it should be stressed that the entire education system is lacking equity and efficiency since only 19% of high school graduates find their way to higher education (Fig. 3). There are many economic-social factors that are causing this low figure: The need of high school graduates to get jobs and help their poor families, lack of financial means to move to cities where universities are located, social resistance of traditional families to send graduate girls to cities.

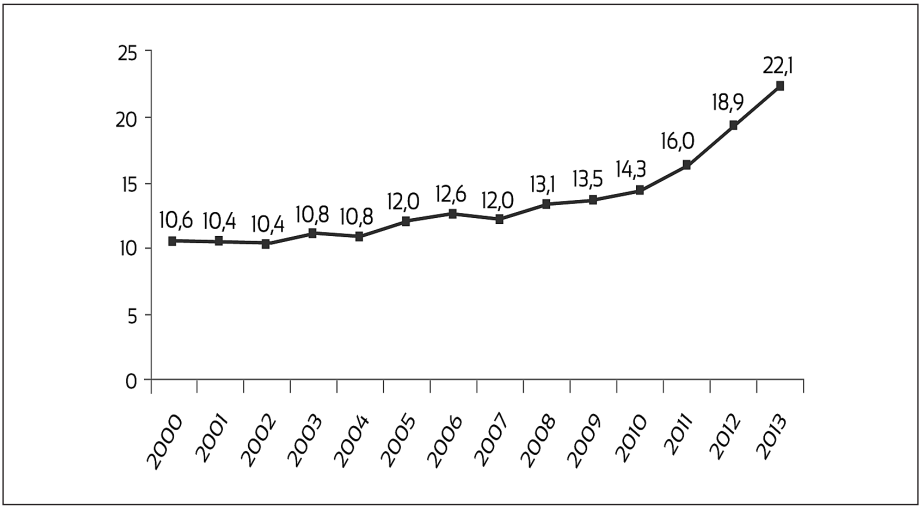

Fig. 3. Evolution of the raw rate of high-school students able to enroll in higher education.
Source: Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015.

This means that 81% of high school students are directly excluded and never reach universities. In addition, 2/3 of the enrolled 19% never make it through university, as students drop without receiving any university degree. Thus, only 6% of all high school students will finish university studies and will get some kind of university degree![1] (Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015).

The contribution of the private sector in meeting the higher education demand increased three folds but is still modest. The newly registered students in the private sector increased from 11,000 to 37,000 between 2000 and 2013 (Fig. 4).

In addition, the private sector is still weak and is struggling to be recognized with the same rights and duties as public universities (Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015; Belfqih, 2000). In fact, public universities and government agencies still do not recognize diplomas delivered by private higher education universities as equivalent to public university-delivered degrees. In addition, striking quality and standard differences exist among public and private higher education institutions.

[1] Data of Ministère de l'Education Nationale, and of Ministère de l'Enseignement Supérieur, de la Formation des Cadres et de la Recherche Scientifique, processed by l'Instance Nationale d'Evaluation, 2015.

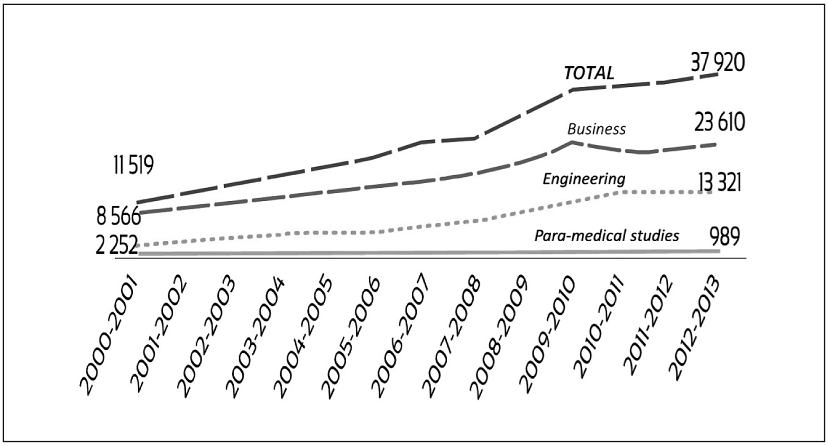

Fig. 4. Evolution of student enrollments in private higher education institutions by field of study.

Source: Ministère de l'Education Nationale and Ministère de l'Enseignement Supérieur, de la Formation des Cadres et de la Recherche Scientifique, 2015.

The fast growing demand for university seats is a continuous burden for the national budget. In fact, during the last 15 years, the total budget allocated to the education sector represented more than one third (30-36%) of the entire national budget (Fig. 5)[2] (Chedati, 2009).

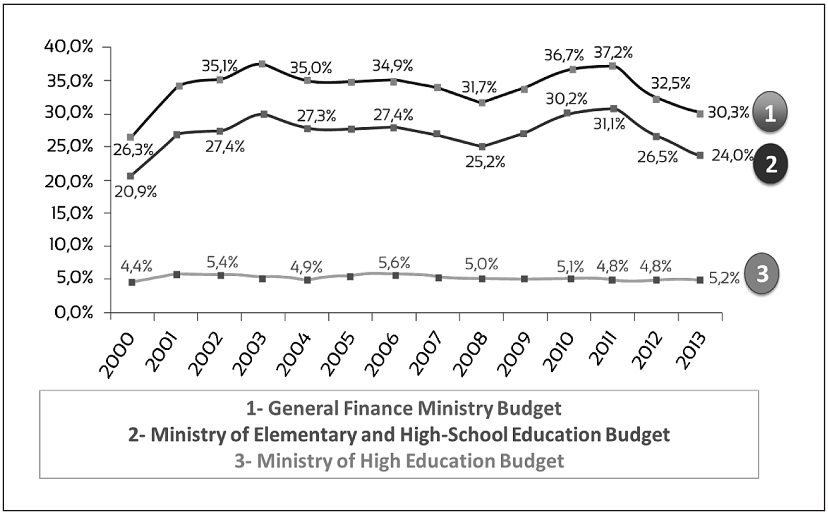

Fig. 5. Respective budget portions in the general budget of national education and higher education.

Source: Belfqih M., 2000 and Chedati, 2009.

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[2] Data of The Law of Finances, General Budget and Budgets of the Ministère de l'Education Nationale and of Ministère de l'Enseignement Supérieur, de la Formation des Cadres et de la Recherche Scientifique.

This indicates that the education sector has high priority and is politically sensitive, as to continue attracting large governmental financial efforts.

IV – Politics and the conflicting interests of stakeholders

Universities are considered the main social ladder by large segments of the population. Universities have always been a major fighting arena among political parties on one hand and between these political forces and government on the other. Political, ideological, religious and ethnic conflicts were created and exacerbated to mobilize youth and professors towards supporting certain political agendas. This resulted in many decisions that handicapped the future of higher education. One of the decisions, made by the Independence conservative party, in control of the Education Ministry, was to move from the Arabic-French bilingual elementary-high school education to the single Arabic system. The experience was a complete failure. An international survey showed that 60% of Moroccan students did not reach the minimum required levels in sciences and mathematics compared to 32% Tunisian and 3% Singaporean students (Fig. 6) (Mullis *et al.*, 2012a, b).

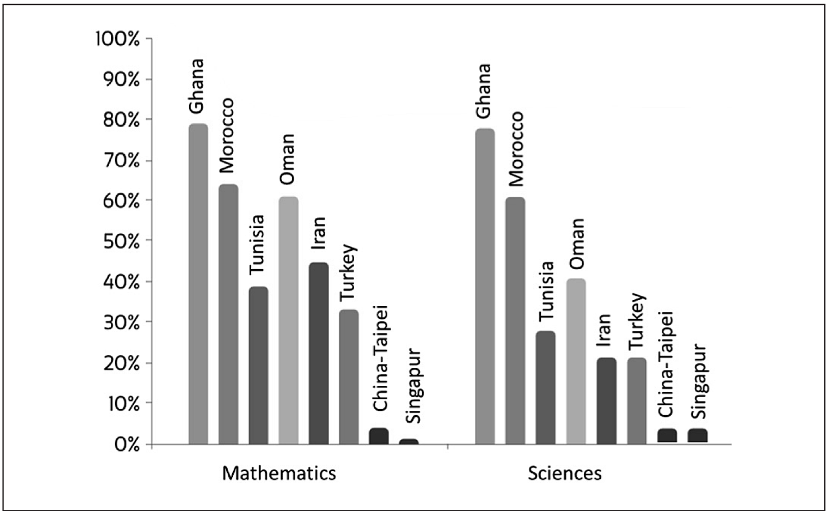

Fig. 6. Proportion of pupils who reached the lower level of competences in 2011 by country.

Source: Mullis *et al.* (2012a, b).

The quality collapse of the elementary-high school education system is a reality and one of the biggest challenges towards the improvement of the Moroccan higher education system.

University students, freshly coming from high schools where they were taught mainly in Arabic, enrolled in engineering, architecture, biology, physics, medicine, or technical universities have difficulties in adjusting overnight to curricula now taught in the French language (it is as if they are changing countries without any special language preparation). On the other hand, students joining Arabic-speaking universities (liberal arts, law and social sciences, etc.) have no language difficulty but face old-fashion pedagogy methods and lack international references (they use mainly Arabic oriented journals, books and supporting materials).

For all the students, the impact goes beyond the language itself and impairs students' capacity for critical thinking and their "cultural fabric": After the independence the Moroccan entire educational system was bilingual (Arabic and French). Overtime, students that where taught in both Arabic and French moved to the use of a single Arabic language. Consequently, students' culture changed from international, open cultural-dimensions to a single more conservative "oriental-middle east" state of mind. In fact, the introduction of a single Arabic language in elementary and high school education system created new generations of students, who were not able to read, understand and access to international literature and culture (use of only Arabic references, books, journals, TV programs, Media, etc.). In spite of all this, another unexpected decision was implemented by the introduction of the Berber language in schools. This was more symbolic, but generated more uncertainty and created another source of confusion.

V – Student and faculty resistance

The degradation of the Moroccan educational system has become a key national issue and a large mobilization, of various forces across political spectrum, was initiated to address this strategic issue. It was decided to introduce an important reform in 2000; the LMD Bologna principles were presented and implemented.

The reform introduced the choice of university presidents and deans via a competitive process instead of the old bureaucratic appointment. On the negative side, most of the selected university presidents, deans and department heads came from academia and had little or no adapted management skills. In addition, faculty support is lacking and for university managers, dealing with "problem faculty" is one of their main concerns. It is striking to notice that a recent survey of 3000 American academic department heads revealed the same findings: that "dealing with problem faculty" was their top concern (Crookston, 2012). It is striking to observe that resistances to changes within universities are as important as the resistances of universities' social-economic environments.

The reform also introduced the review and evaluation of faculty performance and the need for regular curricula changes and program accreditation. Fifteen years later, no systematic review and no faculty evaluations have been carried out, due to faculty resistance and bureaucratic constraints. An update was proposed to the Law 00-01. The first draft of the new reform was rejected, because it was problematic and created polemic religious-political-language concerns, far from student and parental needs. A new proposed reform by the National Evaluation Council is suggesting more modern-progressive innovations and is recommending the need to re-introduce the Arabic-French bilingual system in elementary-high schools, as well as other languages at later stages (English, German, Spanish…) (Conseil Supérieur de l'Education, de la Formation et de la Recherche Scientifique, 2015 ; Belfqih, 2000). On the students' side, the conservative wave is still dominating their agenda. Cultural-political-religious issues outside education attract their attention and create side conflicts that complicate university administrators' job, and distract the whole university system from addressing key education and globalization issues.

VI – Linking to policy-makers and professional partners

There is a large communication gap between professionals and policy-makers on one-side and university professors on the other side. Professional partners complain about the poor qualification of the university graduates. Moroccan business associations repeatedly declare that their needs are not met and most of the graduated students, mainly from the public Open University system, are considered not directly operational and are lacking professional job soft skills. Inadequate curricula and rare interactions with the private sector during student training results in weak acquisition of key job skills. Many surveys showed that professionals are requesting more adapted training and stronger soft job skills (communication, team work, creativity, critical thinking).

Moroccan professionals complain that hired university graduates are not efficient and are lacking needed ready-to-use soft skills (communication skills, competences for teamwork, writing skills, leadership). Similar criticisms and findings are reported worldwide (P21's Framework for 21st Century Learning ; Cyber Summit, 2010; World Bank, 2006).

In contrast to the Open University system, many engineering and management institutes are able to develop links with the private and public sectors and produce a more acceptable and resourceful workforce. These schools are very attractive: For instance, IAV Hassan II receives more than 13,000 applications/year from high school students for 450 available seats (Institut Agronomique et Vétérinaire Hassan II, 2015). More than 95% of graduated students from engineering, business and medical institutes are hired quickly and they get their first job within one year. Again, there are large differences among schools and science fields: agriculture, civil engineering, and management are better off compared to other fields, and their graduates insertion in the job market is more successful.

The capacity of the government and its social partners to mobilize jointly and rapidly in addressing these educational structure matters is vital. Any delay will further weaken universities and drastically limit the economic-social development of the entire country, as the education system provides the needed qualified workforces for all the economic sectors. A successful higher education system needs to be built on three main pillars and adopt an optimum mix of key ingredients and drivers; such mix is derived from errors and wisdom (Fig. 7).

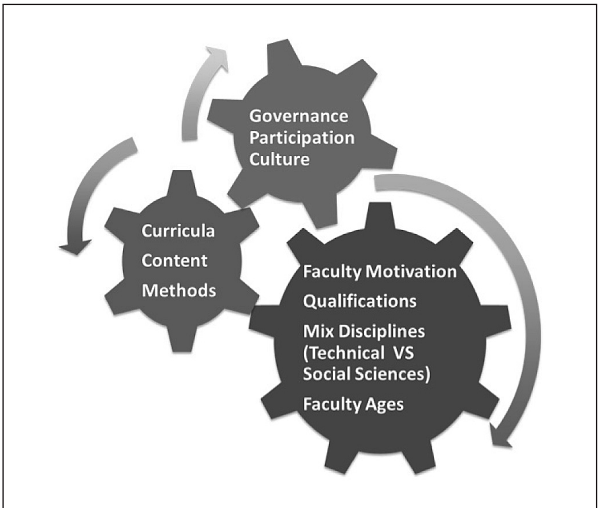

Fig. 7. Three pillars for building a future efficient Training-Research-Innovation system.

Source: Authors elaboration.

VII – Reducing the cultural-dialogue gap

The majority of policy-makers still regard universities as risky institutions producing useless theories and believe that local university faculty members are a constellation of intellectuals disconnected from the real word. On the other hand, university faculty members regard policy-makers as a cluster of incompetent and bureaucratic groups unable to grasp high-technology sciences and the need for changes caused by globalization. The two groups are relaxing in their comfort zones and nurturing their Zen-attitudes. As long as this endless “deaf dialogue” is not over, the reform of the university system will continue to crawl, hindered by this cultural dimension.

VIII – Conclusion

As in many emerging countries, the degradation of the Moroccan educational system has become a key national issue and a large mobilization of various forces across the political spectrum is needed to address the following key challenging education issues.

The education system is facing a rapid growing population demand. The number of registered students in the public higher education system increased drastically from 306,000 in 2010 to 471,000 in 2013 and reached 615,000 in 2015 in the Open University system. These trends will continue in the coming years and the education system is using more than one third of available national financial-budget resources.

In spite of this high public financial spending, it should be stressed that the entire education system is lacking equity and efficiency since only 19% of high school graduates find their way to university higher education. Financial constraints and social family traditions are limiting the access for poor segments of the population that have no means to send their kids to cities for advanced education training.

We also showed that the high education system is a dual and unbalanced system. It includes (i) an inefficient Open University system that enrols 89% of students; (ii) a more efficient competitive system that includes engineering and business institutes (5%); and (iii) the third component is represented by a new weak private system struggling to make its way (6%).

We indicated also that political, ideological, religious and ethnic conflicts were created and exacerbated to mobilize youth and professors towards supporting certain political agendas. This resulted in many decisions in the 80s’, that handicapped the future of the high education system. One of the decisions made was to move from the Arabic-French bilingual education system after the Moroccan independence to the single Arabic system. The experience was a complete failure and the new reform will restore the international bilingual education system.

In addition, meeting the market needs is still a key challenge. Moroccan professionals complain that hired university graduates are not operational and are lacking needed ready-to-use soft skills (communication skills, competences for teamwork, writing skills, leadership). Adapting training and linking university with the business community and the job market are critical for the university survival.

The capacity of the government and its social partners to mobilize jointly and rapidly in addressing these educational key structural issues is vital. Any delay will further weaken universities and drastically limit the economic-social development of the entire country, as the education system provides not only the needed qualified workforces but also more open-tolerant-human-caring citizens.

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Developing the Industry Ready Graduate

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Abstract. Pressure on the global food production chain over the next 40 years will be unprecedented – the demand base is predicted to increase from approximately seven billion today to eight billion by 2030, and to over nine billion by 2050; whilst the competition for land, water and energy will intensify, compounded by the effects of climate change on the availability and suitability of agricultural land. This paper highlights how the lean philosophy and associated techniques as developed in the automotive industry can be applied to arable production systems to minimise waste, and reduce energy and resource input into the system, in particular through the advancing technological developments in agricultural robotics. This will in turn influence the curricular needs for course development in the field of agricultural engineering. Students entering these courses in 2017 will not graduate until at least 2021, and will therefore be required to be industry ready in order that they can produce a timely contribution to the global food security challenge. This will require them to be experienced in problem definition and project management as well as lean production techniques; and to be able to adapt continuously to a changing environment and rapid technological advances – in particular in the areas of systems integration relating to sensor technology, power management and communication protocols. The success of a curriculum designed to produce graduates who have the capability to be deemed as industry ready will be reliant not just on ensuring that the technical content meets the needs of the customer, but also on increasing graduate value through the learning environment by the extension of Bloom's Taxonomy to incorporate that of student motivation and self-belief.

Keywords. Capability – Curriculum – Global food security – Precision agriculture – Lean philosophy.

Pour un diplômé opérationnel dans l'industrie

Résumé. *La pression qui s'exercera sur la chaîne mondiale de production d'aliments au cours des quarante prochaines années sera sans précédent, car on prévoit que la base de la demande augmentera, des quelque sept milliards d'habitants d'aujourd'hui à huit milliards en 2030, et à plus de neuf milliards en 2050 ; tandis que la concurrence pour les terres, l'eau et l'énergie s'intensifiera, composée des effets du changement climatique sur la disponibilité et la mise en valeur de terres agricoles. Cet article souligne comment la philosophie allégée (lean) et les techniques connexes telles que celles développées dans l'industrie automobile peuvent être appliquées aux systèmes de production de cultures pour minimiser le gaspillage, et réduire les intrants en énergie et ressources dans le système, en particulier à travers les progrès technologiques en robotique agricole. Ceci en retour influencera le besoin des cursus de développer des cours dans le domaine du génie agricole. Les étudiants qui entameront ces cours en 2017 n'obtiendront leur diplôme qu'en 2021 au mieux, et donc ils devront être opérationnels pour l'industrie afin de contribuer en temps voulu au défi de sécurité alimentaire mondiale. Il faudra donc qu'ils possèdent de l'expérience en définition de problèmes et gestion de projets ainsi qu'en techniques de production allégée ; et ils devront être capables de s'adapter continuellement à un environnement changeant et à des percées technologiques rapides en particulier dans les domaines de l'intégration de systèmes liés à la technologie des capteurs, à la gestion de l'énergie et aux protocoles de communication. Le succès d'un cursus conçu pour produire des diplômés ayant les capacités pour être considérés opérationnels dans l'industrie, reposera non seulement sur l'assurance que les contenus techniques correspondent aux besoins du client, mais aussi sur l'augmentation de la valeur des diplômés à travers l'environnement d'apprentissage en élargissant la Taxonomie de Bloom pour intégrer la motivation et la confiance en eux-mêmes des étudiants.*

Mots-clés. *Capacité – Programme d'études – Sécurité alimentaire mondiale – Agriculture de précision – Philosophie de l'allégée (lean).*

I – Introduction

The global food system is currently able to provide sufficient food to support the majority of the world's population. However, many of the agricultural production systems are unsustainable in their current form and will potentially lead to degradation of the environment, in turn compromising the capability to maintain and increase food production levels in the future to meet the growing population demands – currently estimated as an increase of 1 billion people by 2030 (Foresight, 2011). The *Future of Food and Farming Report* (Foresight, 2011) highlights the need for innovation and research in the field of agricultural engineering to help address this situation, and in particular that linked to sustainable food production.

Students entering onto degree programmes in 2017 will not graduate until at least 2021, and hence will have less than a decade to make a contribution to this global challenge – and it is therefore vitally important that their education ensures that they are industry ready on graduation. Of concern to this is the 2014 *Engineering and Technology Skills & Demand in Industry Annual Survey*, produced by the Institution of Engineering and Technology (IET), which identifies a further increase in the skills gap for graduates to 54%, with the primary shortfalls being lack of practical experience, leadership skills and technical expertise. Furthermore, the *Jobs and Growth: the importance of engineering skills to the economy* report by the Royal Academy of Engineering (Harrison, 2012) indicates that by 2020 the UK will need to grow its number of graduate engineers by 50% just to meet current demand – and this potentially declining number of graduates further highlights the importance of a high-quality, fit for purpose product.

This paper considers some of the emerging engineering technologies that are being developed to help address the global food security challenge, along with the underpinning philosophies that are being adopted as a result of identified synergies with the automotive industry, in order to propose some core considerations for higher education curriculum development activity.

II – Adopting the lean philosophy through use of hi-tech

The current farming system was developed for maximum crop production after the Second World War, and this model has predominantly remained unchanged. However, with the increasing demand on food and water supply to sustain a growing population; the competition for land mass (habitation, grazing, etc.); and increasingly volatile weather conditions, the global farming industry is now aware of the need to produce more with less (Department for Food and Rural Affairs, 2008).

It is proposed that the goal of a sustainable global agricultural system can be achieved by applying lean philosophies alongside the development and implementation of hi-tech equipment. Lean principles (gaining more from less) can be utilised to define the optimal solution for agricultural production processes; with hi-tech equipment facilitating the implementation of these optimised solutions. The hi-tech element provides the ability to reduce process variability and hence reduce waste, through constraining the behaviour of the system by providing controllability and repeatability.

The requirement for efficient increase in output can be compared to the developments undergone within the automotive industry since the early 1900s, introduced by Henry Ford and subsequently further developed by Toyota. This analogy is strengthened further when also considering pressures such as increased competition from global markets, increases in energy prices, tighter legislation and a desire to have less environmental impact.

Through the implementation of flow production, Henry Ford drastically increased manufacturing throughput, but the system did not allow for variety and led to competitors responding with production systems that re-introduced variety whilst maintaining throughput (Lean Enterprise Institute, 2015). The Toyota Production System (TPS) put the focus on the flow of the product through the entire process, along with identification and optimisation of the value stream, and in so doing continually looked to reduce the number of steps and amount of time and information needed to serve the customer. Lean manufacturing is a management philosophy derived mostly from TPS and is a systematic method for the elimination of waste (referred to as Muda) within a production system, defining value as any action that a customer would be willing to pay for (Womack *et al*, 2007).

With the aforementioned increasing competition for land resource, the capability to increase production will need to focus on optimising the value stream and reducing waste. It is therefore proposed that the challenge to ensure global food security by 2050 can be addressed through the application of lean philosophy to arable production systems.

III – Emerging engineering technologies in agricultural production

The philosophy of lean is well-aligned with the definition of innovation – a new idea or more effective process – and which can thus be viewed as the application of better solutions that meet new requirements or existing marketing needs. The robotics engineer, Joseph F Engelberger (1982), further proposed that innovation only requires: a recognised need; competent people with relevant technology; and financial support. It is therefore important that graduates entering employment in 2021, who will be expected to be able to provide innovative contribution to solving the global food security issues, are competent in their ability to identify customer needs and have the technical competencies to deliver these solutions.

These principles can be applied to all aspects of agricultural production. One area in particular that is embracing the process of establishing need and implementing the lean philosophy through the development of advancing technologies is that of agricultural field robots. The use of a robot enables controllable repetition to a task – and it is this accurate repeatability that gives the reduction in variation and hence the reduction of waste within the system. The development of Controlled Traffic Farming (CTF) is a specific example of where the parallel implementation of lean philosophy and hi-tech equipment can be used to minimise process waste. In traditional 'random traffic systems' – where operators are in control and hence can effectively travel wherever they wish – it is estimated that up to 96% of the field area is compacted by tyres (Kroulik *et al*., 2010). Implementing CTF can reduce this to as low as 15%. This is achieved through use of satellite guidance and auto-steer systems (Bochtis and Vougioukas, 2008), which effectively constrain the operator through removing the ability to go where they want – and hence gaining this reduction in variability.

The increasing size of agricultural machines has been driven by the desire to increase the work rate of agricultural tractors (Gasso *et al*., 2013), in order to counter the pressure from increasing operator costs and reduction in the working time window due to environmental factors. This has, however, also had a detrimental effect on the agricultural production process in terms of its efficiency, through introducing waste into the process in the form of excess compaction and the associated loss of energy with its removal. This can be explained by considering the fundamental science that underpins this machinery implementation, which dictates that for every 1kN of draught force a vertical force of 1kN is required – and hence any increase in implement mass requires an associated increase in the mass of the tractor, which in turn increases soil compaction, and subsequently a larger implement is then required to remove this additional compaction. It is estimated that up to 90% of the energy going in to cultivation is there to repair the damage caused by large machines (Blackmore *et al*., 2004). It is therefore clear that the ever-increasing vehicle mass and non-optimised trafficability are significant causes behind increased energy losses and inefficiencies within the system.

As already identified by TPS, an important aspect of reducing waste is to ensure a focus on the core, value-adding aspects of the process and to minimise waste, and this can be translated in to the development of an underlying principle for agricultural production of focussing on the needs of individual plants.

The production process can be viewed as four main stages – crop establishment; crop scouting; crop care; and selective harvesting – with lean philosophy applied to each as follows:

1. Crop establishment – the development of lightweight, autonomous seeding robots

Implementing the underlying principle of reducing waste by not compacting the ground unnecessarily, current development platforms have reduced the ground pressure to less than 40kPa (compared to a human walking footprint of 110kPa) under the contact patch, which minimises agronomic damage even when the ground is at field capacity, and facilitates crop establishment which is not limited by weather condition – and hence increases the working window. Further to this, ensuring that the robot can accurately position each seed through use of accurate navigation technology:

- Ensures that crop position is known, and further that anything else can be identified as a weed by default, and thus facilitating orthogonal inter row mechanical weeding;
- Facilitates use of multiple, small robots to plant crop synchronously – again increasing the working window.

2. Crop scouting

In order to understand the needs of individual crops, it is critical to have sufficient and as near-real-time data as possible. This need is driving the application of advances in sensor technologies to gather this information as follows:

- Visible: Crop cover, growth rates, flooding extent, late emergence, weed patches, rabbit damage, nutrient imbalance;
- Non-visible: NDVI, thermal, multispectral.

The sensors can traverse the crop areas autonomously through Unmanned Ground Vehicles (UGVs) and Unmanned Aerial Vehicles (UAVs), allowing for specific robot applications to be developed such as:

- Phenotyping robots – to facilitate crop trials to evaluate new genotypes
- Crop scouting robots – to provide targeted agronomic measurements, through incorporation of technology such as thermal cameras (to indicate irrigation status), multispectral cameras to provide nutrient status, and Lidar to scope canopy extent and density.

3. Crop Care

The current practice of organic-mechanical weeding is very expensive (approx. £1000/hectare) and needs to be repeated on three separate occasions throughout the growth cycle. The aforementioned precision planting and resulting opportunity for orthogonal inter row mechanical weeding assists to reduce these costs, but developing this principle further is a system called microspraying which also uses this seed map to give initial guidance points, and then uses vision systems to recognise the weeds in the close-to-crop area and then applies chemical in a targeted way solely at these.

A further technological innovation that is being developed is a real-time machine vision system that can destroy weeds by identifying and then heating the growing point of the weed using a laser system – ultimately reducing herbicide application by 100%.

4. Selective Harvesting

It is estimated that up to 60% of harvested crop is not of saleable quality, resulting in significant amounts of wasted product even before the product has reached the point of exposure to the consumer (Farrell, 2015). Again applying lean philosophy, agricultural robots are under development that can identify and selectively harvest only that part of the crop which has 100% saleable characteristics, and ultimately that can grade, pack and sort for size, sweetness, ripeness, shelf-life, etc. at the point of harvest autonomously and hence add value to products on-farm, minimising downstream processing and hence removing waste from the system.

IV – Graduate capabilities

Having previously highlighted the need for graduates to be competent at identifying customer requirements and scoping problem definition, it is evident that they will be further required to be increasingly capable in the technical areas of machine vision, systems integration (e.g. sensor technology, communication protocols, power management), machine intelligence and programming.

There is, however, only a relatively short timeframe to transition a student from 'unknown and variable' when they enter higher education to a graduate who is operating effectively, and it is therefore of importance that the curriculum makes the most efficient use of the time available. It is further evident that the emergence and adoption of technology is advancing at an ever increasing pace and that graduates will reach a period when they will be working with technology that can't be anticipated and hence cannot be taught as part of the curriculum (Fig. 1).

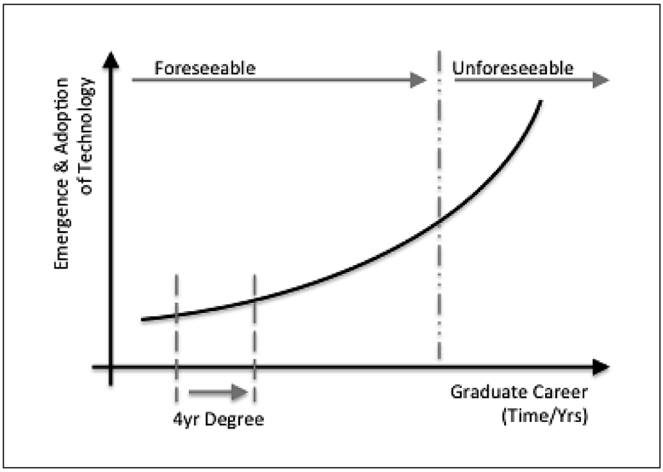

Fig. 1. Increasing pace of technology emergence and adoption vs graduate career duration.

It can be concluded that in order to best prepare graduates who can adapt to current and future challenges, the curriculum must establish a strong foundation in engineering know-how (engineering science, energy transfer, etc.) and must also develop in the students a capability to self-learn that which they will be required to know in the future.

It is therefore proposed that the definition of an industry ready graduate is someone that has the:

- *Capability* to identify customer need and manage projects;
- *Capability* to find, evaluate and synthesise information;

• *Capability* in the underlying core fundamental principles relating to:

 – Technical application,

 – 'Lean' thinking.

Whilst the vast majority of higher education courses would indicate that these aspects are contained within their degree programmes, and hence graduates, the Institution of Engineering and Technology survey (2014) suggests that this view is not supported by employers, and it is proposed that it is the understanding and development of graduate *capability* that is the misalignment. Employers expect that a graduate who is industry ready on graduation will be capable of approaching an unfamiliar task independently, and hence it is proposed that such a graduate has to:

• be capable of undertaking such a task;

• *believe* that they are capable.

Higher education (HE) programmes typically focus on prescribing and assessing specific core content, with this approach primarily supporting the former. Whilst the approach does also contribute in part to building their self-belief, this is predominantly limited to familiar scenarios. It is proposed that this is a factor in the apparent discontinuity between employers and HE providers with regards to their perception of graduates – in that whilst students may be technically capable, they may not be sufficiently motivated or confident to apply themselves to an unknown situation (if students have never experienced learning an unknown, how will they know that they can). A curriculum designed to produce industry ready graduates will therefore need to incorporate the requirement for students to learn and apply technology which they haven't been taught in order to develop their self-belief.

Bloom's Taxonomy is used by higher education curriculum developers as an underpinning framework for developing learners who are able to synthesise and evaluate, and it is often believed that the ability to apply knowledge in this way infers capability. It is further proposed that this model is not sufficient, and that Bloom's Taxonomy needs to be extended in order to achieve capability, through ensuring that graduates also have motivation and self-belief – and that it is these that ensure that capability is actually achieved, and in so doing that graduates have the experience and confidence to produce problem solutions to unpredictable applications (Fig. 2).

V – Conclusion

The realisation of a sustainable global agricultural system will rely on the implementation of precision technologies. The rate of change of technology is such that industry will require input from people who are proficient with the latest developments in these technologies, and hence will be reliant upon students who have been exposed to cutting edge research in these fields.

Students currently considering undertaking a higher education degree programme will not enter the agricultural engineering industry until at least 2021. If the global food security challenge is to be met by 2030, then students entering higher education programmes at this time will have less than 10 years of their early career to contribute in any meaningful way. In order to accelerate the delivery of the food security solution, students therefore need to be industry ready at graduation.

In order to achieve this output, the education process needs to be restructured to facilitate early capability. It is proposed that whilst Bloom's Taxonomy remains a good foundation for constructing a higher education curriculum, in order to satisfy current needs the taxonomy needs to be extended to enable undergraduates to be able to achieve this capability at graduation. To achieve this, curriculum delivery must also nurture motivation and self-belief.

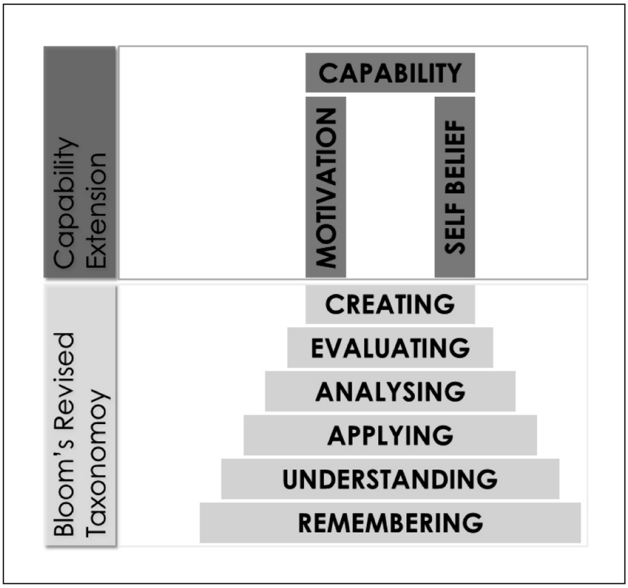

Fig. 2. Bloom's Revised Taxonomy with Capability Extension.
(Source: adapted from Anderson and Krathwohl, 2001).

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Relevance of biotechnologies in agriculture curricula

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Abstract. Agriculture must adopt technological innovations to respond to the social demand of sustainable increase of food production. Among these innovations there will be a set of emerging biotechnologies that will contribute to respond to this demand and to reach additional goals like improving food quality and developing biological systems with enhanced resistance to diseases and environmental stresses in a global warming scenario. Our current knowledge on livestock genomes, and the development of computational biology, omics and gene editing technologies will provide novel tools to face agriculture challenges. The drivers of this novel green-"omics" biotechnological revolution should be the current and future students of the higher education systems, and therefore the implementation of programs to tackle these challenges and to improve the biotechnological skills and knowledge in their curricula will be essential to respond to agriculture needs. Also, a better understanding of agriculture market demands and of the complex process of products development should be included in agriculture curricula. Moreover, stronger interactions between higher education students and agriculture professionals and stakeholders will be required to fulfil the current gap between the education systems and the bio-economic sector. Additional efforts should be devoted to explain to the society the basis of agricultural production and the essential contribution of biotechnologies and other technological innovations in improving agricultural productivity, human life quality and social progress.

Keywords. Biotechnology– Higher education– Computational biology– Agriculture.

L'importance des biotechnologies dans les cursus agricoles

Résumé. *L'agriculture doit adopter les innovations technologiques afin de répondre à la demande sociale d'accroître la production alimentaire selon les principes de durabilité. Parmi ces innovations figureront une série de biotechnologies émergentes qui contribueront à couvrir ces besoins et à atteindre des finalités additionnelles telles que l'amélioration de la qualité des aliments et le développement de systèmes biologiques ayant une plus forte résistance aux maladies et aux conditions environnementales adverses dans un scénario de réchauffement global. Notre savoir actuel sur les génomes des animaux d'élevage, et le développement de la biologie computationnelle, des sciences omiques et des technologies d'édition de gènes constitueront de nouveaux outils pour affronter les défis de l'agriculture. Les moteurs de cette nouvelle révolution biotechnologique des omiques vertes devraient être les étudiants actuels et futurs des systèmes d'enseignement supérieur, et par conséquent la mise en place de programmes pour relever ces défis et pour améliorer les compétences et le savoir en biotechnologie dans les cursus sera un élément essentiel pour répondre aux besoins de l'agriculture. De même, une meilleure compréhension des demandes des marchés agricoles et du processus complexe de développement des produits devrait être intégrée dans les programmes d'études liés à l'agriculture. De plus, des interactions plus fortes entre les étudiants de l'enseignement supérieur et les professionnels et parties prenantes de l'agriculture sera nécessaire pour combler le fossé existant actuellement entre les systèmes d'enseignement et le secteur bio-économique. Des efforts additionnels devraient être faits pour expliquer à la société les fondements de la production agricole et la contribution essentielle des biotechnologies et des autres innovations technologiques à l'amélioration de la productivité agricole, de la qualité de la vie humaine et au progrès social.*

Mots-clés. *Biotechnologie – Enseignement supérieur – Biologie computationnelle – Agriculture.*

I – Introduction

Population experts anticipate the addition of another approximately 3 billion people to world population by mid-21st century. Food and Agriculture Organization of the United Nations (FAO) estimates that agriculture will need to produce about 70% more food than it currently does to fulfil the demands of this expanding population (FAO, 2009). The general consensus is that traditional crops and farming methods could not sustain that much productivity (Fedoroff *et al.*, 2010). Moreover, the dramatic increase in global food demand will growth together with an enhanced demand for feed, biomass and biomaterials. Also, agriculture must deal with decreasing natural resources and the negative effects of climate global warming, that will impact agricultural production, the changes in global demographic and the need for providing a sustainable, safe and secure food supply for human population. It should be a social priority to provide agriculture and forestry with the fundamental knowledge and tools to develop resource-efficient and stress resistant biosystems that will supply food, feed and other biobased raw-materials without compromising ecosystem services (Brookes and Barfoot, 2008).

Nonetheless, agriculture is a significant contributor to climate change. Agriculture and food production represent 40% of the total global industrial energy demand, while global agriculture represents 14% of total greenhouse gas emissions. Among the agriculture goals should be the improvement of the adaptive capacity of plants, animals and biological systems to biotic (new diseases and pests) and abiotic stresses, the conservation and use of biodiversity, and the implementation of measures at farm, forest and landscape level to mitigate specific stresses associated to global warming such as water scarcity, heat and highly saline soils. In addition, research must promote the sustainable management of soils, exploit the current advances in conservation agriculture and reduce greenhouse gas emissions from agriculture and forestry activities.

Recent reports of The World Bank on food security and crop yield emphasize the gains that can be made by bringing existing agronomic and food science technology to people without it, by exploring the genetic variability in our existing food crops and by developing more ecologically farming practices (Bellagio Meeting, 2007). This requires building local educational, technical and research capacities, food processing and storage capabilities, and other aspects of agribusiness, as well as rural transportation and water and communications infrastructure, but also involves addressing the regulatory issues that interfere with trade and inhibit the use of novel technologies, like biotechnologies. The private and public research sectors are doing significant efforts to implement and apply to breeding the conventional and more recent molecular technologies, as well as the genetic modification (GM), to adapt our existing food crops to increasing temperatures, decreased water availability in some places and flooding in others, rising salinity, and changing pathogen and insect threats (World Bank, 2008; Gregory *et al*., 2009). Biotechnology will be essential to respond to these novel breeding goals.

However, one potential barrier of applying biotechnologies to agriculture is the perception that society has currently of these technologies and the almost unique association of plant biotechnology with GM crops, as revealed by several social biotech surveys and barometers. For example, the seventh Eurobarometer survey on life sciences and biotechnology indicates that: (i) Europeans are mostly rather positive about biotechnology; (ii) Europeans feel that they lack basic information on important biotechnology issues; and (iii) all decisions on biotechnology should be rooted in sound science and take due account of ethical, health and environmental factors. The main conclusion of this study (Eurobarometer, 2010) is that Europeans citizens are in favour of responsible innovation with appropriate regulation to balance the market, but also that there is a major communication challenge that should be filled at the Education Systems. Notably, since 2005 Europeans have increased their confidence in doctors, scientists, the EU, national governments and industry, to do a good job in taking decisions on biotechnology issues. In the survey, 53% of respondents believe biotechnology will have a positive effect in the future (particularly in human health), and only 20% said that this effect might be negative. The survey also reveals important knowledge gaps, pointing to a need for more communication: a majority of respondents had never heard of some of the emerging biotech-associated areas such as nanotechnology (55%), bio/germoplasm banks (67%) and synthetic biology (83%). More importantly for agricultural innovation, the survey showed that a clear majority of Europeans (61%) remains opposes to GM food. There was strong opposition, with only 18% supporting animal cloning for food. However, there is cautious support for GM food applications, with 46% of respondents in favour and 38% opposite, but a clear majority of Europeans (61%, up from 57% in 2005) remains broadly opposed to GM food. There is a critical need to get beyond popular biases against the use of agricultural biotechnology and to develop forward-looking regulatory frameworks based on scientific evidence, as this perception could negatively impact the implementation of novel biotechnological tools for improving food and feed supply (Stein *et al*., 2009).

In this communication we describe our current view of the relevance of biotechnologies in the agriculture curricula of the current and future students of the higher education system. We also describe our own experience on implementing Biotechnology curricula at the Universidad Politécnica de Madrid (UPM), and present some of the results obtained in a survey carried out with Biotech undergraduate students, which intended to identify the specific skills that they consider should be added to their curricula. The survey data show that the Biotech curriculum students consider essential the improvement of their professional skills and their interaction with the productive sector for better career opportunities, and also that acquiring biotechnology knowledge will strength their professional succeed.

II – Materials and methods

In the frame of the Biotech2020 Initiative of the Biotechnology and Plant Biology Department from the Universidad Politécnica de Madrid, we performed a survey to identify the opinion of bachelor students demands for their curricula improvement. This survey consisted of a questionnaire to third-year students of Biotechnology Bachelor from the academic years 2013-2014 and 2014-2015. The questionnaire was done in a specific meeting and was followed by individual interviews by the Biotech2020 panel of experts. The respondents were students of any of the three different Biotechnologies specializations: Plant Biotechnology (n = 12), Computational Biotechnology (n = 11) and Health Biotechnology (n = 46). The questionnaire included several prioritizing questions aimed to identify putative gaps in students technical, scientific and professional formation, and to determine their current preferences for their future professional careers. Among the proposed answers to the main question ("what are the more relevant aspects that the student considered to improve his/her curricula") were the following: (i) scientific and biotechnical basic formation; (ii) practical training in biotech companies; (iii) legislation and business knowledge and skills; (iv) research and development practical training in Universities and Institutes; (v) postgraduate academic studies (Master and Doctorate); (vi) academic and professional mentoring and; and (vii) professional skills. The descriptive analysis and the graphical representations of the results were done based on the top ranked answers given by the students.

III – Results and discussion

1. Emerging biotechnologies in the agriculture higher education curricula

The application of novel technologies to agriculture to achieve a "sustainable intensification" is in the agenda of governments and international bodies (Gruskin, 2012). However, in parallel there is a global trend towards increased regulation of new technologies in agriculture, particularly biotechnologies. One of the reasons explaining this increasing regulation and developmental barriers is that agriculture and forestry are unique systems delivering commercial products but also wider non-marketed ecological and societal public goods. These manifold roles and the non-market value of agriculture and forestry livestock, including supporting the provision of important non-material benefits to society (landscapes and recreation) as well as of ecological goods and services, should be compatible with food and feed production.

The available **annotated genomes** of most livestock species and the decreasing price for sequencing offer unprecedented opportunities for advances in evolutionary biology, animal and crop breeding and even in the development of animal models for human diseases studies (Federoff, 2010; Gruskin, 2012). Technical developments in breeding, nutrition, and health in agriculture livestock (animal, crops and microorganisms) will contribute to increasing potential production and further efficiency and genetic gains. Molecular genetics tools are likely to have considerable impact, in particular marker assisted selection for traits that are difficult to measure, such as food and feed quality, resistance to disease and environmental stresses and improved fertilizers uptake.

The use of new technologies is occurring at fast pace, however with different level of advancement in the world, in particular for innovative breeding (**new plant breeding techniques)**. Genome editing or site-directed mutagenesis techniques as well as the use of epigenetics and gene silencing are already under experimentation in the public and private sectors (Lusser *et al*., 2012). Additional tools like synthetic promoters, "tunable" transcription factors, and the use of site-specific recombinases will also impact agriculture development. The potential to enable crop improvement by using methods such as the assembly and synthesis of large DNA molecules, plant transformation with linked multigenes and the generation of plant artificial chromosomes, could be consider as the first step from agriculture to synthetic biology. The first crops obtained through these new breeding techniques are close to commercialization, but only if the regulatory issues for the commercialization of these novel crop varieties are clearly established, the adoption of these techniques by breeders will definitively occur (Lusser *et al*., 2012; McDougall, 2011; Miller and Bradford, 2010; Stein *et al*., 2009).

A better understanding of the interaction of agricultural biosystems (crops, animals a microorganisms) with other organisms (beneficial or not) in the environment is essential to mitigate yield loses caused by disease, pests and weeds, and to exploit the beneficial interaction of crops and animals with their associated microorganism (**microbiomes**; Sessitsch and Mitter, 2015). The understanding of these interactions will benefit agriculture as some of these microbiomes could improve the nutrient uptake and the response of agricultural biosystems to biotic and abiotic stress, as it has been suggested to occurs in human (Hacquard *et al*., 2015). The design and generation of synthetic microbial communities for specific crops should be addressed and the specific biotechnologies associated and required for this type of innovation must be included in the agriculture curricula. Similarly, the soil and the microorganisms it contained must be considered as a biological system relevant for crop production, and therefore has to be studied using the new genomic and computational tools as a required step for its conservation and sustainable exploitation (Sessitsch and Mitter, 2015).

Biologists are joining the **big-data** club and developing the **computational biology (**Marx, 2013)**.** With the advent of high-throughput genomics, life scientists are starting to grapple with massive data sets, encountering challenges with handling, processing and moving information that were once the domain of astronomers and high-energy physicists. To build new understanding of physiological aspect of agriculture biosystems or even of natural ecosystems, scientists must be able to analyse oceans of new (big) data generated by genomic sequencing, imaging, and other advanced technology. Upper-level science and undergraduate and master students will need skills in writing computer programs, working with databases, and applying complex statistics and modelling to agriculture biosystems.

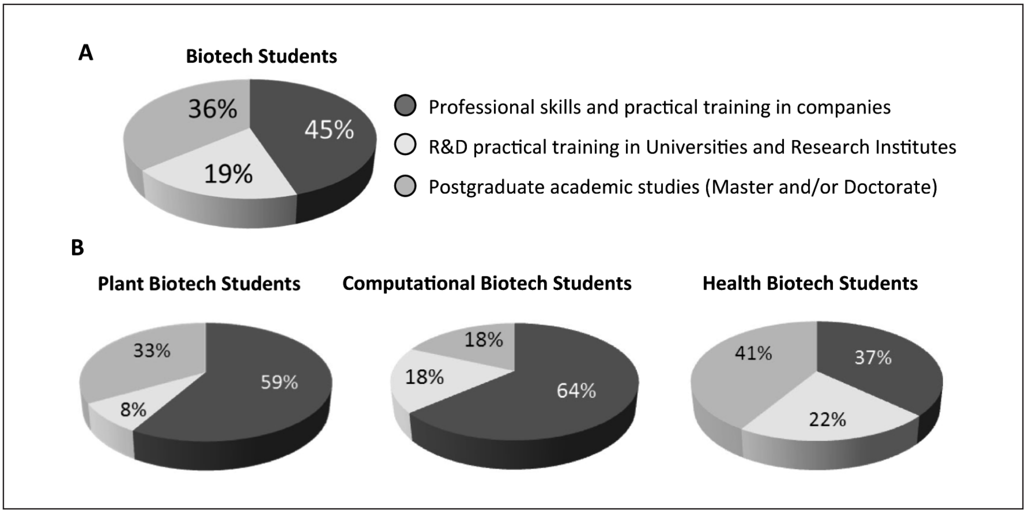

Fig. 1. Relevant knowledge and skills that the UPM Biotechnology Bachelor students considered have to be improved in their curricula for a competitive professional carrier.
Representation (in percentages) of the prioritized areas considered relevant for the UPM Biotechnology Bachelor students to improve their curricula in relation to their putative professional carrier. (**A)** Responses of all the students (n = 70), and **(B)** distribution of these responses in the different biotechnology specialization: plant, computational and health biotechnologies.

New research orientations are emerging in **behaviour science approaches** to agricultural development (World Bank, 2008). These new orientations are the product of both experience gained during the era that followed the Green Revolution and a response to changing goals in agricultural development that now place a greater emphasis on considerations of participation and equity. Use of ecological systems approaches to the study of farming systems is increasing. The importance of understanding traditional agriculture is becoming evident and technology development methodologies are beginning to simulate farm conditions at the research centres and to conduct experimental research on the farms. The appreciation of technology as a variable is leading to the development of alternative technologies adapted to different socio-natural situations. In this scenario biotechnologies could have significant contribution.

2. Moving biotechnologies and students out of academia into agriculture

The plethora of new concepts and biotechnologies indicated above should be included in the student agriculture curricula to respond to social and economic demands, but it might not be sufficient to respond to the professionals needs of future agriculture drivers, and to agriculture challenges (Langer, 2014). In the frame of the educational initiative program (EIP) BiotecH2020 (http://www.bit.etsia.upm.es/biotech2020.htm), we have carried out a survey among students from the Biotechnology Bachelor of the Universidad Politécnica de Madrid (UPM) to determine their perception about curricula needs. As shown in Fig. 1A, the students perception was mainly focused in three areas: (i) Professional skills and practical training in companies (45% of students); (ii) Postgraduate studies, that means further specific formation (36%); and (iii) R&D practical training in Universities and Research Institutes (19%). These data indicate that the students consider the acquisition of professional skills in companies and the specific formation (Master and PhD) in the biotech sector essential for their professional carrier. Of note, the percentage of the biotech students considering that the acquisition of professional skills in companies is important for their curricula is higher in those students enrolled in the Plant and Computational Biotechnology specialization than in the Health Biotech one (Fig. 1B). Notably, despite we have included a strong program of lab practical training and experimental Bachelor Thesis during the four years of the Biotechnology Grade, our perception, and that of the students, is that they would need to carry out more lab practices either in privates companies or public research institutes to acquire the professional expertise necessary for their professional future, especially for those students interested in biotechnology companies careers.

The BIotecH2020 EIP data also suggest that the students consider that they need to move biotechnologies out of the academia and into the industry. However, this remains a mystery to many scientists (Langer, 2014). What's more, knowledge of the commercial sector in academic circles can lag many years behind present business practice, especially when industry models are in constant evolution. Most life science researchers simply are not trained in the complexities of product commercialization (Langer, 2014; McDougall, 2011). In our opinion, properly educating more researchers to understand entrepreneurship and to have the skill needed to succeed in the commercial world is essential for translating discoveries into products, building companies and also providing the knowledgeable recruits that industry wants to hire. These needs are of special importance in the area of biotechnology (Langer, 2014).

The establishment of the undergraduate Biotechnology Program at the UPM was one of the strategic objectives included in the UPM BIOTECH Initiative launched in 2010 and aiming to provide biotechnology education skills to the students at earlier curricula steps to improve their knowledge and to increase their professional opportunities in the Biotech sector. This initiative was supported by the excellent results obtained with those students that have completed either the UPM Master and/or PhD Biotech Programs (Biotechnologies in Agricultural and Forestry (http://www.bit.etsia.upm.es/master_en.htm), and Biotechnology and Genetic Resources of Plants and Associated Microorganism; http://www.bit.etsia.upm.es/doctorado.htm). More than 90% of these students got a job in the first year after their completed their Master or PhD formation, and they had the opportunity to initiate their professional career in different departments (R&D, regulatory affairs, marketing, teaching, entrepreneurship, etc.) of either private or public bioeconomy entities, including those related with agriculture, food and biotechnology. This experience of more than 10 years further supports the professional competitive advantages of including biotechnologies in the Agriculture curricula.

In parallel to the BIOTECH Initiative, the UPM has tried to include Biotechnology formative programs in all life science-related curricula, including the Agriculture, Food and Forestry ones. However, the majority of the Biotech subjects in these curricula are optional and the number of students enrolled in these Biotech topics is far from optimal. In other Spanish Universities with Agriculture curricula we have found a similar situation. We consider that the lack of basic biotech knowledge and skills of the current Agriculture Bachelor students is unfortunate since we guess, based on our experience, that this formation would be required for their professional career development.

3. School Education systems: learning life science and understanding biotechnology

New educational approaches might be required to introduce biotechnology and biology at primary and high schools, and universities. In the current educational system, students are listening to lectures on photosynthesis, memorizing parts of the cell, and learning the terms of taxonomy, DNA and genetics, and biotechnologies (Bonde *et al*, 2014). While biological research is advancing at warp speed, amassing new insights and new data as the lines separating biology, chemistry, mathematics, and engineering dissolve and the fields converge.

Urge to take a new approach: in the place of courses based solely on lectures and memorization, schools and universities should incorporate the latest practices of biological research, engaging students with the opportunity to think and work like scientists on issues with real-world relevance. Thus, the students will feel that they're part of the science community, and that they're learning things that can be related to the real world. They should be challenged to *think.* The transformation of biology and biotechnology education from elementary school to universities, will be essential to support biotechnology, biomedicine, and other sectors that will be essential for 21st-century innovation and economic growth. Without that, the risk is that leadership of innovative countries in these fields will diminish, at great economic cost (Bonde *et al*, 2014).

IV – Conclusions

Biotechnology can make an enormous contribution to main agriculture goals such as reaching sustainable yield growth and providing food and feed for healthier life. Therefore, we consider that biotechnology must be a key subject in Agriculture Curricula Programmes. The Agriculture curricula should also consider that improving the professional skills and training of the students is essential to respond to agriculture and society needs and demands.

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Role of quality assurance and programme accreditation in supporting development of innovative agricultural curricula

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Abstract. An increasing global demand for food security and sustainability places substantial responsibility on higher agricultural education institutions. Quality assurance, accreditation, and innovation are central elements for the development of agricultural curricula. Most scholars agree that student learning is core to the role of the university. Quality judgements are framed around four criteria-academic scholarship, demands of the subject matter, relevance to society, and viability. Quality assurance is enhanced by peer-evaluation, rigorous research, and confirmation by student evaluation data. Quality assurance also recognises the contributions that research makes to the growing body of scientific knowledge. Accreditation strengthens trust affirming the purpose, experiences, organisation, and measured scalable learning outcomes. Policies for accreditation should recognise internal and external standards, provide user protection, provide independently-verified information, and improve and enhance the culture and values of the people. The proposed framework fits national qualifications into a comprehensive common system of quality assurance, learning outcomes, recognised programme standards, cultural values, and accreditation. Innovation is crucial for curriculum viability. Measurement is essential for an improvement strategy in education. Faculty reward systems must match the academic functions. Six crucial concepts underpin the development and execution of innovative agricultural curricula.

Keywords. Agricultural curricula – Bologna Process – Disruptive innovation – Program accreditation – Quality assurance – EHEA.

Rôle de l'assurance qualité et de l'accréditation de programmes pour le soutien au développement de plans novateurs d'études agricoles

Résumé. *Une demande mondiale croissante pour la sécurité alimentaire et la durabilité place une responsabilité importante sur les institutions d'enseignement supérieur agricole. L'assurance qualité, l'accréditation et l'innovation sont des éléments centraux pour le développement de programmes agricoles. La plupart des spécialistes conviennent que l'apprentissage des élèves est au cœur du rôle de l'université. Les jugements de qualité sont articulés autour de quatre critères – savoir académique, demande du sujet d'étude, pertinence pour la société, et viabilité. L'assurance qualité est renforcée par une évaluation par les pairs, une recherche rigoureuse, et la confirmation par des données d'évaluation des élèves. L'assurance qualité reconnaît également les contributions que la recherche apporte à la masse croissante des connaissances scientifiques. L'accréditation renforce la confiance en affirmant le but, les expériences, l'organisation et les résultats d'apprentissage évolutifs mesurés. Les politiques d'accréditation doivent reconnaître les normes internes et externes, assurer la protection de l'utilisateur, fournir des informations indépendamment vérifiées, et améliorer et renforcer la culture et les valeurs du peuple. Le cadre proposé intègre, dans un système commun complet d'assurance qualité, les qualifications nationales, les résultats d'apprentissage, les normes des programmes reconnus, les valeurs culturelles et l'accréditation. L'innovation est cruciale pour la viabilité des programmes. La mesure est essentielle pour une stratégie d'amélioration de l'éducation. Les systèmes de récompense des professeurs doivent correspondre aux fonctions académiques. Six concepts cruciaux soustendent le développement et l'exécution des plans novateurs d'études agricoles.*

Mots-clés. *Plans d'études agricoles – Processus de Bologne – Innovation de rupture – Accréditation de programmes – Assurance qualité – EHEA.*

I – Introduction

The opportunity to examine the role of quality assurance and programme accreditation in supporting development of innovative agricultural curricula between two "core" regions, the US and Europe, has been rewarding. As we begin, we should remind ourselves of the founding purpose of higher education. As the oldest university in Europe, founded in 1088, the University of Bologna stated its purpose: to establish a "*societas di socii*" –groups of students– and was declared a place where research could develop independently from any other power" (Università di Bologna, para. 3). However, there has been tension regarding the purpose since its founding. Boyer (1990) began an essay "by looking at the way work of the academy has changed throughout the years –moving from teaching, to service, and then research" (p. xi). Boyer continued, charging that "the faculty reward system does not match the full range of academic functions and that professors are often caught between competing obligations" (p. 1). So, while roles of quality assurance and programme accreditation are purposed to benefit primarily the student and to advance knowledge independently, there are competing interests.

Agricultural curriculum is defined in this paper as the programme of study specified both by the university and the academic level, including the courses and related experiences, necessary for the degree. Tyler (1949), in a classic description of principles of curriculum and instruction, asked four framing questions to guide the development of innovative curricula; they remain relevant: "(i) What educational purposes should the school seek to attain? (ii) How can learning experiences be selected which are likely to be useful in attaining these objectives? (iii) How can learning experiences be organised for effective instruction? (iv) How can the effectiveness of learning experiences be evaluated?" (pp. v-vi).

With that background, we begin to explore and deconstruct the roles of quality assurance and programme accountability.

1. Delimitations and assumptions

This paper is focused primarily on internal quality assurance and external programme accreditation related to agricultural universities and programmes. The paper includes discussion of adapting to disruptive innovations in knowledge transfer. Geographically, this paper is delimited to American (US) and Western European universities and programmes. The authors assume that globalisation, competitiveness and mobility trends will continue to correlate to population growth, impacts of technology, environmental degradation, migration-immigration, and global conflict.

II – Quality assurance

Admittedly, quality is complex, multidimensional, and difficult to measure, but it plays a crucial role in the development of innovative agricultural curricula.

With the notion that form follows function, Boyer (1990) encouraged quality assurance by taking seriously the scholarship of integration, application and, especially, instruction. Helms (2015) argues that "development and operation of international education partnerships and programs should be guided by a multifaceted quality assurance framework" (p. 14).

Van Damme (2002) argued that if academic quality has a meaning, it has to be defined in relation to the core meaning of academic learning. Consequently, student learning (broadly defined as what students do) and teaching (what teachers do) are inextricably linked and interdependent processes (Scott, 2008).

Quality assurance has stakeholders within the academy and external publics beyond the academy. Most, but not all, agree that quality is an essential element and that judgments are framed around four assessment criteria: (i) Academic scholarship (teaching, research, service); (ii) Demands of the subject matter; (iii) Relevance to society; and (iv) Viability.

Van Damme (2002) noted that "twenty years of expertise and operational experience in quality assurance in higher education have not lead [*sic*] to a growing consensus on how the concept of quality should be defined, on the contrary. There is much more diversity in the definition of the concept than ever before, while we need to converge on what we actually mean by academic quality. The current prevalence of the relativist 'fitness for purpose' model and also the 'consumer satisfaction' approach, popular among new providers, only serves to avoid this difficult question" (p. 43).

The European Association for Quality Assurance (ENQA) is committed to respect the fitness for purpose principle (purpose-process alignment) that is at the core of the European dimension of quality assurance.

1. Quality assurance for Faculties

Using Boyer's work, Weiser (1995) developed a quality assurance framework incorporating teaching and learning, discovery, artistic creativity, integration, and application. Weiser recognised mission and responsibilities, saying "scholarship is creative intellectual work that is validated by peers and communicated" (p. 6).

Vukasovic (2014) recognised internal quality assurance as having regulative, normative and cultural-cognitive dimensions. Thune (2009) countered saying, "'quality assurance' is a generic term in higher education which lends itself to many interpretations: It is not possible to use one definition to cover all circumstances" (p. 12).

Rosa *et al.* (2012) recognised five complementary purposes for quality assessment related to internal staff perceptions: communication, motivation, control, improvement, and innovation. In a study of Portuguese academics' perceptions, Rosa *et al.* found strong staff support for improvement, communication and innovation purposes related to quality assessment. They found less support for motivation and control purposes.

Academic quality indicators reveal and confirm the quality and the relevance of the curriculum to society and to improve where necessary. Quality assurance is enhanced by peer-evaluation and rigorous research, as well as student evaluation data. Quality assurance also recognises the contributions that research makes to the body of scientific knowledge. These quality indicators must include Web of Science citation impacts, domain-specific niche research, professional publications in the niche, such as Scopus (SCImago, 2007) and Google Scholar (2015), and practical products with utility for public good. The weights of these indicators should match the philosophy, mission and goals of the faculty.

Relevance to the student and the society is a crucial indicator of quality assurance. Indicators of research rigour include peer review criteria, impact factors, and journal rankings.

Viability is a quality assessment surrounding the strategy that the curriculum intends to pursue in the years ahead and the extent to which it is capable of meeting its targeted needs of students and society during this period.

Van Damme (2002) advised that core concepts of academic quality may differ if used as a regulatory device in different environments. Vukasovic (2014) reported that disciplinary differences matter. Vukasovic found regulative elements were not very important in "hard-applied fields" while the regulative aspects are a necessary condition for further institutionalisation in the "soft-applied fields" (p. 44).

2. Quality assurance for Universities

UNESCO, as an external stakeholder, defined quality assurance in higher education as "a systematic process of assessing and verifying inputs, outputs, and outcomes against standardized benchmarks of quality to maintain and enhance quality, ensure greater accountability and facilitate harmonization of standards across academic programs, institutions, and systems" (UNESCO, 2008, p. 2).

Van Damme (2002) argued, "Only such a concept will be able to survive in the global educational marketplace. It is also the only way to defend the sense of identity and community in the higher education world against the danger of fragmentation entailed by diversification processes. The risk for not developing such a definition is the annihilation of real academic quality interests in a globalised higher education market or their reduction to mere consumer satisfaction concerns. Thus, there is need for a broad international consensus on what actually the core standards of academic quality should be" (p. 11).

The quality concept frequently serves very different purposes. Sometimes the concept of quality is misused in order to standardise and homogenise academic contents and curricula.

3. Summary of quality assurance

Kristensen (2010) examined external quality assurance over a 20-year period and concluded that although external quality assurance has improved, the greatest challenge to future quality in higher education is balance and synergy between internal and external quality assurance while meeting the obligations of internal assurance. She advocated audits be mandatory at the national level. At the same time, Kristensen argued "the role of the external quality assurance is too dominate" [*sic*] (2010, p. 156). In the final analysis, quality assurance benefits from equilibrium between internal and external forces. However, the sway should favor internal influences, innovation, and increased student learning.

III – Accreditation

Accreditation is an idea with 17th Century roots in middle French as "*trustworthiness*." A search for a common framework for higher education accreditation resulted in a diverse set of purposes, processes, actors, and vocabulary –the French might say, "*courir lapins*" or running rabbits. The broader "core" purpose for accreditation is to recognise and endorse quality education at the institutional and programme levels while branding counterfeit entities.

Accreditation includes an array of public and private relationships that affect students, faculties, governments, professions, and the larger public. Separately we will examine the purposes, processes and stature, and actors, including accreditation organisations versus private ranking agencies in Europe and the US.

Among European and US higher education, there are three principal frameworks that influence quality assurance and accreditation: (i) external agencies in the US; (ii) internal governmental agencies in Europe; and (iii) privy councils or sovereign bodies in the UK. GOV.UK (2015) listed institutions that can offer degrees by virtue of their own degree awarding powers or those powers of another institution.

1. Purposes of accreditation: Europe

The evolution of the European vocabulary of accreditation includes synonyms that must be interpreted carefully. Assessment, audit, benchmarking, certification, competencies, EQAR, indicators, learning outcomes, licensing, outcomes, qualification frameworks, REHEQA, and standards each have special and occasionally unique meaning (Vl! sceanu, Grünberg and Pârlea, 2007). Accreditation, like quality assurance, is complex, multidimensional and is sometimes difficult to manage, but it plays an essential role in the development of innovative agricultural curriculum.

In most European countries the function of educational accreditation for higher education is conducted by a governmental organisation, such as a ministry of education. For example, the University of Bologna holds its accreditation from the Ministry of Education, Universities and Research in Italy.

Thune (2009) warned, "Quality assurance can be undertaken by external agencies for a number of purposes, including: safeguarding of national academic standards for higher education; accreditation of programmes and/or institutions; user protection; public provision of independently-verified information (quantitative and qualitative) about programmes or institutions; and improvement and enhancement of quality" (p. 15).

Thune (2009) reported that during the July 2003 Graz Declaration of the European University Association (EUA), 13 countries agreed that "the purpose of a European dimension to quality assurance is to promote mutual trust and improve transparency while respecting the diversity of national contexts and subject areas" (p. 13). Thune (2009) reported the 2003 Berlin communiqué invited the European Network for Quality Assurance in Higher Education (ENQA), in cooperation with the EUA, EURASHE, and ESIB, to develop an agreed-upon "set of standards, procedures and guidelines on quality assurance and to explore ways of ensuring an adequate peer review system for quality assurance and/or accreditation agencies or bodies, and to report back" (Thune, 2009, p. 5) to the Bergen ministerial conference in 2005. Since that time, the recent Montenegrin Qualifications Framework (MQF, 2014) reported that "higher education is an activity of public interest and, therefore, all institutions have to have an accreditation and a license, regardless of their ownership" (p. 17).

The MQF (2014) announced, "System monitoring and evaluation at the higher education level is also carried out by means of external and internal quality assessment mechanisms, i.e., through procedures implemented in various stages, starting from initial accreditation, through monitoring of teaching process to reaccreditation of higher education institutions in Montenegro" (p. 36). ENQA (2015) declared a commitment to respect the fitness for purpose-process alignment is at the core of the European dimension of quality assurance and accreditation. Thune (2009) noted that "agencies should pay careful attention to their declared principles at all times, and ensure both that their requirements and processes are managed professionally and that their conclusions and decisions are reached in a consistent manner, even though the decisions are formed by groups of different people" (p. 26).

Stensaker (2011) warned, however, that "the range of accreditation in European higher education may be more complex than is often imagined, and that one should be careful about drawing quick or straightforward conclusions about the role accreditation plays, with respect to internationalisation, globalisation, and 'Europeanisation'" (p. 764).

Stensaker (2011) reported that, "although accreditation is mentioned in these [*sic*] central Bologna process, it is worth noting that the concept of accreditation is only put forward as one of several possible elements the countries participating in the Bologna process were expected to consider. If we consult the European Standards and Guidelines..., there are no references made to specific methods for quality assurance: it calls for external 'quality assurance mechanisms designed specifically to ensure their fitness to achieve the aims and objectives set for them.' Regarding methods, these standards only specify the need for 'periodic reviews', based on 'explicit published criteria'" (p. 759).

A second and closely related issue is that both US and European external quality assurance is facing increasing criticism for failing to address issues concerning student learning outcomes (Ewell 2008; Tremblay, Lalancette, and Roseveare, 2012/2013; Alexander, 2015; Stensaker, 2011).

“A third issue, involving the different contexts surrounding accreditation in Europe and the US, is that while accreditation is criticized for not being improvement-oriented enough in the US it could be argued that the current spread of accreditation in Europe is an indication of increasing interest in control and compliance with academic standards” (Stensaker, 2011, p. 765).

Thune (2009) advised, “All external quality assurance processes should be designed specifically to ensure their fitness to achieve the aims and objectives set for them” (p. 9). In this case, external quality assurance may well include accreditations or audits. Thune continued, “The need for external quality assurance to be fit for its purpose and to place only an appropriate and necessary burden on institutions for the achievement of its objectives” (p. 11). Stensaker (2011) posited, “Accreditation is becoming one of the most popular methods for external quality assurance worldwide” (p. 757).

2. Purposes of accreditation: US

In the United States the 100 year-old quality assurance process is independent of government and performed by private associations, but it is interrelated to the US Department of Education (USDE). There are four types of accrediting organisations: (i) regional accreditors, (ii) national faith-related (i.e., religious) accreditors, (iii) national career-related accreditors, and (iv) programmatic accreditors. Each has a unique mission and audience. Alexander (2015) noted, “Accreditation is, at its core, an effort by colleges and universities to self-regulate. As the landscape of higher education evolves –from the students served, to the providers that deliver education, to the expectations of consumers– so too must accreditation” (p. 11).

Eaton (2009) reported, “In the United States, accreditation is carried out by private, nonprofit organizations designed for this specific purpose” (p. 1). Contrary to internal quality assessments, “Accreditation is a process of external quality review created and used by higher education to scrutinize colleges, universities and programs for quality assurance and quality improvement” (p. 1). Further, she wrote that accreditation carries out the following roles: assuring quality; enabling access to federal and state funds; engendering private sector confidence; and easing credit transfer (mobility)” (pp. 2-3).

Recognition in the United States is about scrutiny of the quality and effectiveness of accrediting organisations. It is carried out by the higher education enterprise through the Council on Higher Education Accreditation (CHEA), a private body, and by government (USDE) (Eaton, 2009).

As an umbrella organisation, the CHEA provides recognition in the private, nongovernmental sector and is associated with 52 recognised national accrediting bodies and six principal regional agencies. There is a plethora –more than 75– of specialised and professional accreditors, some with excellent credentials, which are loosely associated with CHEA.

USDE (2015) described accreditation in the United States as “a voluntary, nongovernmental process, in which an institution and its programs are evaluated against standards for measuring quality” (para. 1). CHEA recognition is funded by institutional dues while USDE recognition is funded by the US Congress.

The goals of the two entities are different: CHEA assures that accrediting organisations contribute to improving and maintaining academic quality; USDE assures “that accrediting organisations contribute to maintaining the soundness of institutions and programmes that receive federal funds” (Eaton, 2009, p. 9) “The two recognition processes are similar: self-evaluation based on standards, site visit and report, and the award of recognition status. Recognition adds value to society as a vital part of accreditation accountability or ‘accrediting the accreditors’” (Eaton, 2009, p. 9).

The University of California-Davis, recognised for excellence, is accredited by the Accrediting Commission for Senior Colleges and Universities of the Western Association of Schools and Colleges (WASC). WASC is an institutional accrediting body recognised by the Council for Higher Education and the US Department of Education. Additionally, the UC-Davis (2014) General Catalog reported programmes accredited by 20 separate accrediting boards or commissions. The 20 agencies represent medicine and nursing (9), law (3), education and teacher credentialing (2), and engineering and technology (1), and five others.

As a regional accrediting agency, the Southern Association of Colleges and Schools Commission on Colleges (SACSCOC, 2015) posts its mission is "to assure the educational quality and improve the effectiveness of its member institutions" (para. 1). Further, the association lists six core values: "integrity, continuous quality improvement, peer review/self-regulation, accountability, student learning, and transparency" (para. 3).

3. Processes and stature of accreditation

Accrediting agencies**,** which are private educational associations of regional or national scope, have developed evaluation criteria over time and conduct peer evaluations to assess whether or not those criteria are met.

Accreditation signals to the public that the institution and/or programme meet recognised standards of quality and is a symbol of prestige. The process begins with a request for a rigorous internal and external evaluation and institutions or programmes that meet an agency's criteria are then "accredited" by that agency.

A. EHEA / Bologna Process

European higher education quality is a national responsibility and the statutory powers reside within national or sub-national legislation. To fully understand the processes, it is necessary to first understand the higher education policy developed and implemented at the individual national level by the relevant ministry of the country (ECApedia, 2015).

However, European cooperation was strengthened with the promotion of the Bologna process and the Lisbon Strategy. This cooperation has led to gradual common targets and initiatives, which are supported by a number of funding programmes. Funding bodies, such as the EU, have no legal power, but rather are subordinated to national legislation and policy.

As an EU initiative, the overarching European Qualifications Framework (EQF) fits national qualifications into a comprehensive common system of quality assurance, learning outcomes, recognised program standards, and accreditation (ECApedia, 2015).

While 47 signatories and eight consultative members of the European Higher Education Area (EHEA) committed to developing National Qualifications Frameworks (NQF, 2010; (EHEA, 2015a), considerable work remains to be done. The NQF is undergirded by individual national qualifications frameworks that reflect the NQF as well as cultural conventions, students, academic freedoms, and economic policies. These are contentious issues. A current progress report is available at the EHEA website (EHEA, 2015c). EHEA members generally benefit from increased recognition and prestige for their institutions, a sense of collective engagement and ownership, and increased mutual trust, control, professional autonomy, and accountability. However, this is not undisputed.

The EQF external quality assurance included eight ENQA criteria. "Activities may involve evaluation, review, audit, assessment, accreditation or other similar activities and should be part of the core functions of the member" (ENQA, 2014, p. 1).

B. CHEA/USDE Process

Accreditation in American higher education began as a peer review process in the late 19th century concerned about articulation among secondary schools and college entrance requirements. The post-WWII focus shifted more to regional agencies, in concert with the federal government, as examiners for quality assurance and protection for federal funding. Today the process is a collaboration among private non-government accrediting agencies to affirm and enhance academic quality and the Secretary of Education to publish an approved list of quality institutions of education. Although accrediting agencies may accredit foreign institutions, USDE has no jurisdiction outside the United States. CHEA (2010) reported that more than 19,000 programmes and 7,000 institutions were accredited by 80 recognised organisations in 2008, impacting more than 24 million students.

The step-wise process for accreditation begins with the application by the institution. The accreditation agency reviews and accepts/rejects the application based on compliance with principles of integrity, core requirements, comprehensive standards, federal requirements and the policies of the agency. The initial regional accreditation begins "four phases in the process for securing initial accreditation – (1) building a foundation of understanding as the institution starts the process, (2) preparing the Application for Membership, (3) hosting the Candidacy Committee, and (4) hosting the Accreditation Committee" (SACSCOC, 2011, p. ix). The typical timeline for initial accreditation is four years.

Like EHEA, US accreditation provides greater recognition of their institutions, assurance to students, a feeling among faculties of ownership, collective engagement, and trust a professional autonomy and control, as well as accountability (SACSCOC, 2011).

4. Accreditation actors

European actors in the quality assessment and accreditation of higher education included the respected Ministers and their staff and an array of governmental and stakeholder acronyms including, but not limited to, BFUG, BUSINESSEUROPE, Education International, EQAR, and the E4 group (EHEA, 2015b). These governmental actors are responsible for quality assurance, involving stakeholders, and encouraging dialogue on funding and governance of higher education.

Individual country-states have bodies with authority and responsibility of quality and accreditation. An example is The Accreditation Organisation of the Netherlands and Flanders. As an independent accreditation organisation, the organisation "was set up by the Dutch and Flemish governments. It evaluates the quality of higher education in the Netherlands and Flanders according to objective criteria" (Niessen, 2012, para. 7).

There is a tension between accreditation holding accreditors accountable and directing and prescribing the process (CHEA, 2011). Fritschler (2008) reported "Accreditors and the universities with which they work face a daunting challenge: They are responsible for assuring accountability to the public through traditional methods of self-regulation and they are facing increasing pressure from the federal government to impose prescribed accountability measures" (p. 1).

A. Private ranking agencies

Private world rankings may be a disruptive innovation. The QS World University Rankings by Subject in 2015 "evaluated 3,467 universities and ranked 971 institutions. The rankings are prepared by Quacquarelli Symonds (QS), a British firm that previously was the data provider for the annual Times Higher Education rankings. The firm is widely considered to be one of the most influential international university rankings providers" (UC-Davis, 2015). World rankings are also reported by US News & World Report (2015) and methodologies are reported by Morse and Foster (2014).

Western Europe has chosen to endorse programmes using external quality assurance constructs –with quite different approaches. Wageningen University and Research Centre, founded in 1918, ranked the best global university for agricultural sciences by *US News & World Report* and third by QS World University Rankings, is institutionally accredited by the Dutch-Flemish Accreditation Organisation (NVAO).

Niessen (2012) reported the NVAO evaluated Wageningen UR "on five standards, including the institution's vision on the quality of education, the policy it develops in this area (including the attention for facilities) and the embedding of education in the international professional field. Other criteria are the systematic manner in which the university improves its education and the presence of an effective decision-making structure for educational quality, which includes input from students" (para. 4).

QS World University Rankings recently ranked University of California-Davis number 1 in the world for teaching and research in agriculture and forestry for the second consecutive year (*US News & World Report* ranked UC-Davis second in the agricultural sciences). The UC-Davis Biological Systems Engineering programme was ranked second best global programme by QS World University Rankings. The Biological Systems Engineering programme is accredited by ABET.

ABET is a professional, non-governmental and non-profit organisation, recognized by CHEA, that accredits individual programmes of study, rather than evaluating an institution as a whole, and provides assurance that a college or university programme meets the quality standards established by the profession for which the programme prepares its students. ABET accredits over 3,100 programs in applied science, computing, engineering, and engineering technology at more than 670 colleges and universities in 24 countries (ABET, 2015). ABET accreditation is voluntary, fee-based, and achieved through a peer review process.

6. Current status of accreditation

A. EHEA – Yerevan Ministerial Conference

Accreditation hinges on two issues: (i) the development of international competitiveness through integrated policies and programmes; and (ii) adjustments resulting from student mobility, mutual recognition agreements, and new delivery modes. Accreditation as a quality assurance model can provide at least a part of the answer to these two challenges.

In its 16th year, The EHEA Bologna process held its Ministerial Conference and 4th Bologna Policy Forum in Yerevan Armenia (Klemenčič and Ashwin, 2015). In the conference, ministers and stakeholders discussed the NQF, self-certification of the MQF, youth employment, and future challenges of the MQF (2014) "based on learning outcomes and its key role is to reform and modernise the qualifications system by connecting education and labour market and by ensuring quality of attained qualification" (p. 75).

B. US – Reauthorisation of HEA

While accreditation in the United States is more than 100 years old, there are challenges calling for change related to three major concerns: accountability, costs, and the changing structure and delivery of higher education.

ACE (2015) reported, "Since the original Higher Education Act (HEA) was created in 1965, the sweeping law governing federal financial aid programs has been rewritten eight separate times. The current HEA was set to expire at the end of 2013 but has now been extended through 2015 while Congress prepares for the next reauthorization. Among the issues that likely will be included in the final bill are affordability and college costs; access, persistence and completion; better information for consumers; student loan programs; accreditation and oversight; innovation; and the burden of federal regulations" (para. 1). ACE has worked with Congress on each reauthorisation and has already taken initial steps on the current process.

Recently, the US Senate released white papers in an effort to focus attention on accreditation to the upcoming reauthorisation of the HEA. The papers focused on student consumer information requirements, risk-sharing in the student loan programmes, and accreditation.

Knoester (2015) reported "The US Senate seems intent to refocus accreditation to become mostly aimed at improvement and to scrap some of its accountability functions. In white papers released by the Senate Committee on Health, Education, Labor and Pensions, accountability functions such as the link between accreditation and institutional eligibility for federal student aid and the powers of the Department of Education when it comes to the recognition of accrediting agencies are questioned. To promote competition it is suggested to eliminate the geographic-based structure of regional accrediting agencies, thereby ending the monopoly on institutional accreditation that these agencies have in their region. Innovation should be encouraged by opening up accreditation to non-college providers of higher education" (para. 1).

General consensus points to the need to "redesign and reform accreditation to strengthen the quality of colleges and universities, promote competition and innovation in higher education, and provide accountability to government stakeholders and taxpayers" (Berkes, 2015, para. 3).

7. Analysis

A. Pro –European EHEA / Bologna process

The original 1999 Bologna meeting set in motion goals for comparability of standards and quality of higher education qualifications. In the implementation report of the Bucharest Ministerial Conference (EHEA, 2012), Commissioner Vassiliou concluded that "the Bologna process has transformed the face of European higher education" (p. 7). The report continues, saying, "the Bologna Process has induced change at systems level through the implementation of trust building tools aimed at increasing transparency across national jurisdictions and at bringing about convergence of systems" (p. 9). Areas of noted accomplishment include degrees and qualifications, quality assurance, social dimensions, effective outcomes and employability, lifelong learning, and mobility. With optimism, Klemenčič and Ashwin (2015) reported significant progress from the Yerevan Ministerial Communiqué. "One is fostering employability of graduates. The other objective is to make higher education systems more inclusive" (p. 2). "New is the objective of enhancing the quality and relevance of learning and teaching" (p. 3). Klemenčič and Ashwin praise the ministers saying "This is the first time that quality of teaching and learning has been emphasized in such strong and unambiguous terms" (p. 3).

B. Con –European EHEA / Bologna process

Grove (2012) wrote to conclude that "Bologna not to taste of German critics" (para. 1). Arguments included Grigat charging "that changes introduced under the programme to harmonise European higher education systems had undermined institutional autonomy and universities' ability to educate students to high standards" and "this notion of 'competence'...is only about markets, not about developing what is special about the person" (para. 5), "It has missed all its objectives – student mobility has not increased, study time has not decreased and employers complain about graduate skills" (para. 7). Sturm, in Groves article, declared, "Bologna had added an extra layer of bureaucracy for academics" (para. 8). In a counterpoint, Schulze said, "the changes in German higher education were not down to Bologna" (para. 11). "We are responding to something that has been happening for 30 to 40 years–the massification of universities. Those who graduate from these ‘competence’ universities are not doing any worse than those from more traditional educational universities” (para. 12).

Coleman (2006) citing Block and Cameron, warned that “Globalization influences both language use and the economics of HE. It is a complex phenomenon, with positive and negative social impacts, embracing economics, culture, identity, politics and technology” (p. 1), (Block and Cameron, 2002, pp. 2-5).

Van Damme (2002) expressed concern that variations in QA systems in different countries make it unlikely that mutual recognition arrangements would be valid without some streamlining and alignment of systems. Those who rely on recognition or validation arrangements to signify “equivalence” need to be reassured that valid comparators underpin such arrangements. Progress over the past 13 years has reduced QA variations while recognising and accommodating the unique culture, values and investments of individual EHEA members.

Fritschler (2008) recognised accreditations’ dilemma of serving two masters: universities and governments.

C. Pro –US accreditation process

CHEA (2013) argues that accreditation is a highly successful and well-tested system of quality assurance and quality improvement. Further, it is an outstanding example of an effective public-private partnership and of reliable and responsible self-regulation. There is substantial argument for non-governmental accreditation with a minimum of partisan influence.

D. Con –US accreditation process

The US publics have moved from an era of historical trustworthiness and judgments to a culture of measurement, evidence, performance and impact. The Higher Education Act of 1965 (PL 89-329) was sweeping legislation that has been rewritten eight times. Congress is preparing for complex reauthorisation, including accreditation, in 2015.

Today’s vocal critics argue that accreditation in its present form, particularly regional accreditation, must be changed. (Alexander, 2015; Berkes, 2015; Broad, 2015; Dickeson, 2006; Leef and Burris, 2002; Lucas, 1996; Schray, 2006; Spellings Commission, 2006).

Alexander (2015), as chair of the committee to reauthorise 2015 legislation, issued a challenging white paper. He criticised current accreditation policy for failing to document student learning, lacking academic rigour, limited student engagement, a lack of basic skills, student attainment and achievement, and workforce skills. Further, Alexander charged that accreditation can inhibit innovation and competition, citing anti-competitive policies and resistance to change using massive open online courses (MOOCs), technology, distance delivery, hybrid curricula, and student-centered learning as examples. His declared strategy was to “redesign and reform accreditation to strengthen the quality of colleges and universities, promote competition and innovation in higher education, and provide accountability to government stakeholders and taxpayers” (p. 1).

Alexander (2015) concluded the critical white paper with three options for restructuring accreditation: (i) refocus accreditation on quality; (ii) redesign accreditation to promote competition and innovation; and (iii) keep recognition of accrediting agencies independent and free from politics. If approved as part of the 2015 Congressional reauthorisation of higher education act, there will be massive changes in actors, policy, authority, limits, costs, and practice.

8. Summary of accreditation

While the purpose of quality assurance expanded over a 20-year period, the expectations of accreditation have also increased. Quality assurance is of broad interest between internal and external stakeholders. Likewise, the process of accreditation is of interest by a diverse audience. Clearly, accreditation trends have increased the roles, scope and actors. Accreditation faces the challenge of integrity, balance, and synergy while recognising tradition, change, and innovation. There is an expectation that accreditation go beyond nominal attributes (e.g., counting students, books, credits, and compliance) and measure ratio attributes (e.g., purpose, experience, critical thought, learning outcomes, reflection, pedagogical innovation, democracy, and values).

> *"If you can measure that of which you speak, and can express it by a number, you know something of your subject; but if you cannot measure it, your knowledge is meager and unsatisfactory."* – William Thomson, (Lord Kelvin)

IV – Innovation and the development of agricultural curricula

Innovation, sometimes disruptive, in curriculum development is essential for progress and often comes from the margins of the academy. Innovation (n.d.) with roots from Latin "*innovationem*," is defined as, "a new method, idea, product; something new or different introduced" (para. 1). The capacity to measure innovation is key to improvement in education.

Christensen and Eyring (2012) posited, "Historically, higher education has avoided competitive disruption. One reason for this past immunity is the power of prestige in the higher education marketplace, where the quality of the product is hard to measure" (p. 47). Further, Christensen and Eyring predicted, "Universities that survive today's disruptive challenges will be those that recognize and honor their strengths while innovating with optimism. University communities that commit to real innovation, to changing their DNA from the inside out, may find extraordinary rewards. The key is to understand and build upon their past achievements while being forward-looking" (p. 47).

Rogers (1962/2003) introduced systematic theories of diffusion arguing that diffusion is communicated through certain channels over time among participants within a social network. Rogers identified the principles, including adopter categories, characteristics of social structures, characteristics of innovations, decision stages, and consequences while recognising challenges of bias and equality that influence the rate of adoption of innovation. Recent advances in social network analysis (SNA) further explain and expedite innovation. Gladwell (2002) acknowledged, "The success of any kind of social epidemic is heavily dependent on the involvement of people with a particular and rare set of social gifts" (p. 33). Historically, agricultural sciences exemplified innovation and the social networking that accelerated innovation in agriculture and education.

Govindarajan and Trimble (2010, 2012, 2013) have a decade of research examining innovation and transformations in global business and industry. In their parable, "*How Stella saved the farm: A tale about making innovation happen*", they warned, "the idea is only the beginning" and "just go make it happen" is a woefully inadequate approach for innovation. Further, they describe the importance of "building the team" and "planning and assessing progress" (2013, p. 157). Govindarajan and Trimble (2010) expound on six crucial concepts that underpin the parable and offer valuable insight on the development and execution of innovative agricultural curricula.

Christensen (2015) explored "disruptive innovation" from a business perspective and described "a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors" (para. 1). Christensen, Horn, Soares and Caldera (2011) examined online education as an emerging disruptive innovation and concluded, it "presents an opportunity to rethink many of the age-old assumptions about higher education" (para. 2). Bush and Hunt (2014) convened more than 19 renowned global thinkers to explore economics and access to higher education in a conference focused on globalisation of higher education. They too recognised the many opportunities, including scale, access, and costs. Christensen (2014) asked, "Why do we care?" (42:30). He explained if we assume that one vector drives prices down and the second vector represents non-consumption in the marketplace; there will be huge changes in economic growth, competition, technology. Christensen concluded to the faculties, "God bless you; you are the front line" (46:30).

V – Promising practices

Our overarching purpose was to respond to the global challenge in knowledge transfer in order to meet world demands for food security and sustainability. This paper examined the role of quality assurance in supporting the development of innovative agricultural curricula. Peripheral issues included accountability, control, professional autonomy and trust. Seven promising quality assurance practices emerged from this inquiry:

- Curriculum is the guidebook for student learning and it begins with purpose, experiences, systematic organisation, and measured learning outcomes. Faculties are the process leaders on the front line.
- While student learning is the raison d'être, quality is the defining element for higher education.
- Student learning and quality teaching are inextricably linked and interdependent processes.
- Ultimately, four assessment criteria explain university priorities–academic scholarship (teaching, research, service), demands of the subject matter, relevance to society and viability.
- Quality assurance is enhanced by peer-evaluation and rigorous research, as well as student evaluation data. Baseline indicators include teaching, research and public good.
- Improvement, communication and innovation are drivers of quality among professors, while motivation and control have less impact.
- The two greatest challenges to future quality in higher education are balance between continuity and change and synergy between internal and external assurance while meeting the obligations of public trust.

This paper also examined the role of programme accreditation in supporting development of innovative agricultural curricula. Six promising accreditation practices emerged from this inquiry:

- Accreditation is a bond of trust affirming the purpose, experiences, organisation and measured, scalable learning outcomes.
- Accreditation should accurately delineate standards using qualitative and quantitative measurements and boundaries.
- Policies for accreditation should recognise internal and external standards, provide student protection, provide independently-verified information, and improve and enhance quality.
- All external quality assurance processes should be designed to guarantee their suitability to achieve the aims and objectives of the institution.
- Institutional accreditation should be free of political influence while being responsible to stakeholders.
- Framework should fit national qualifications into a comprehensive common system of quality assurance, learning outcomes, recognised programme standards, cultural values, and accreditation.

Innovation is essential for curriculum viability. This paper examined innovation as a process that brings together novel ideas in a way that have a positive impact on society. Five promising innovation practices emerged from this inquiry–

- Innovation is crucial to the development of curriculum.
- The ability to measure innovation is key to a long-term improvement in education.
- Faculty reward systems often do not match the academic functions and professors are often caught between competing obligations.
- Six crucial concepts underpin the development and execution of innovative agricultural curricula.
- Technology, including online education, is well positioned as a disruptive innovation.

Figure 1 illustrates the role of quality assurance and programme accreditation in supporting development of innovative agricultural curricula.

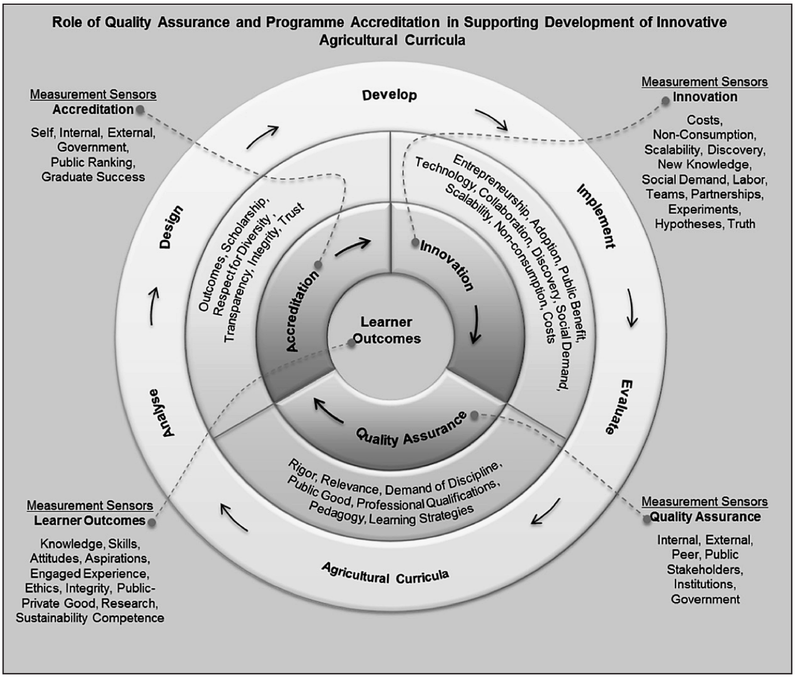

Fig. 1. Integrating quality assurance, programme accreditation and innovation into curriculum development.

VI – Conclusion

We are living in turbulent times. The challenges of 2050 call for innovation unlike any of the past century. Dobbs, Manyika and Woetzel (2015) explained four global forces breaking all the trends –urbanization, accelerating technological change, an aging world population, and global connections. Many of these challenges can be tackled through higher agricultural education –"protecting our environment, enriching our youth, improving our health, growing our economy, and feeding our world" (Texas A&M University, 2015, para. 2). Developing innovative agricultural curricula is at the heart of the solutions. Innovation begins with exploiting Tyler's model (1949) by determining the purpose, identifying the experiences related to the purpose, organizing the experiences, and evaluating the outcomes. As tools for curriculum designers, the phases require designers to analyse, design, develop, implement and evaluate. Forrest (2014) describes each step in the development process.

Drucker (2005) advised, "The greatest challenge to organizations is the balance between continuity and change. You need both. At different times, the balance is slightly more over here, or slightly more over there, but you need both. And balance is basically the greatest task in leadership. Organizations have to have continuity, and yet if there is not enough new challenge, not enough change, they become empty bureaucracies, awfully fast" (para. 1). Drucker (1980) cautioned, "The greatest danger in times of turbulence is not the turbulence – it is to act with yesterday's logic" (para. 1). Engaging the future requires asking the right questions while nurturing communication and collaboration. Pollard (n.d.) posited, "Learning and innovation go hand in hand. The arrogance of success is to think that what you did yesterday will be sufficient for tomorrow" (para. 1). Norman Borlaug (personal communication, May 27, 2008) encouraged our team when facing agricultural development challenges saying, "be bold."

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Session IV
Globalization and International Alliances

China's Higher Education in Agricultural Science. Coping with challenges through transformative models

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Abstract. In the recent past, the last twenty years, a lot of measures were undertaken in driving the development of China's higher agro-education. These included strategies such as modification of developing models, reformation of administrating system, granting of Project "211" or/and Project "985",implementing the Plan of Top Agro-forestry Talents' Training, optimizing the structure of agro-higher education and encouraging to establish world-class universities in agro-science. A preliminary achievement has been realized: three Chinese agricultural universities' ranks, keep on rising in the recent years. Though they originated their destinations as world-class agro-universities, the large gap remains. To cope up with the new challenges, initiative transformative models have been adopted. The models are university institutional re-organizing, setting up overseas joint institutions or programs as the Agricultural Confucius Institute, the establishment of national collaborative innovation agro-centers and New Rural Development Institutes.

Keywords. China – Higher agro-education – Developing model – Challenge.

L'enseignement supérieur de la Chine en Sciences agricoles. Faire face aux défis à travers des modèles transformateurs

Résumé. *Au cours de ces vingt dernières années, beaucoup de mesures ont été prises dans la conduite du développement de l'agro-enseignement supérieur de la Chine, telles que la modification des modèles de développement, la réforme du système de l'administration, le projet "211" et / ou le projet "985", la mise en œuvre du plan formation de talents « Top agro-forestiers », l'optimisation de la structure de l'enseignement agro-supérieur, et l'encouragement à créer des universités de classe mondiale dans l'agro-science. Une réalisation préliminaire a été faite : les rangs de trois universités agricoles de la Chine ne cessent d'augmenter dans ces dernières années, bien qu'un grand écart reste encore à être couvert. Pour faire face aux nouveaux défis, des modèles d'initiatives de transformation ont été adoptées, comme la réorganisation institutionnelle universitaire, la mise en place d'institutions et de programmes internationaux, comme l'Institut Agricole de Confucius, la mise en place de l'innovation d'agro-centres d'innovation collaborative à niveau national, et les nouveaux instituts de développement rural.*

Mots-clés. *La Chine – Agro-éducation supérieur – Développement modèle-défi.*

I – Introduction

The China's higher education in agricultural sciences was initiated over 100 years ago, but most of the agricultural universities in China were founded in 1950s that was during the major reforms of higher education system. As we know, there have been broadly two influential models of higher education around the world: the first model offers a broad and preferably comprehensive range of subjects which is extensively used in UK, USA and much of western continental Europe established institutions; the second model refers to institutions that specialized in one broad field. The Soviet Union actually became the most influential proponent by using this model (Liu *et al.*, 2015). In 1952, influenced by the Soviet Union's higher education developing model, the China's higher education system experienced a major reform, which separated comprehensive universities into different professional realms. They combined common realms from different universities into professional colleges and set up many agricultural institutions which specialize in one broad field. However, since the last quarter of the twentieth century, especially with the collapse of Soviet Union in 1991, the global specialized universities reconsidered their development orientations and took many measures to tangle development issues. This paper therefore focuses on the review of measures that were undertaken and achievements made by China's government and universities for the higher agro-education in the past 20 years and challenges to cope with from the perspective of transformative models.

II – Transformative measures undertaken

1. The modification of developing models

University merging is becoming an increasingly popular restructuring strategy for promoting efficiency, effectiveness, economy and competition in the higher education sector (Mok, 2002). Since the 1990s, the China's higher education system was also reconstructed again by modification. During this period, higher education institutions in agricultural sciences have adopted the following three models to develop to become more comprehensive (Liu *et al.*,2002):

1) Model A: A group of agro-universities (hereinafter denotes universities with agriculture, forestry or ocean in their names) were merged, such as China Agricultural University which was integrated by Beijing Agricultural University and Beijing University of Agricultural Engineering, and Northwest A&F University integrated by seven agro-colleges or institutions, etc.

2) Model M: Several agro-universities were merged into others to be comprehensive universities, such as Zhejiang Agricultural University that was merged into Zhejiang University, Shanghai Agricultural College into Shanghai Jiaotong University, etc.

3) Model S: There were also many universities that were able to keep their independence without merging but widening their subjects, such as Nanjing Agricultural University, Huazhong Agricultural University, etc.

It is approximated that the modification gave rise to the decreasing number of agro-universities from 62 in 1992 to 41 as at now (see Table 1). In this process, a number of large-scale, high-level, and comprehensive agro-universities with a relatively full range of disciplines were established. Independent agricultural universities were also able to develop into multidisciplinary institutions by internal enlarging the fields of subjects. The overall competitiveness of higher education in agricultural sciences has been promoted.

2. The reformation of administrative system

Successful efficiency initiatives in all sectors are characterized by corporate, government or sectoral "mandate". Mandate means that there is a defined and clear authority and leadership to request a particular course of action, make decisions, take responsibility for outcomes and instigate the change required in an organization or sector (Universities UK, 2011). In order to modify the inconsistent management of the central and local governments in higher education, and the overlapped administration of school running, a major reform on the administrative system of higher education was effected in 1990s. Formerly, higher agricultural education institutions were once attached to the China's Ministry of Agriculture, and they have been all detached from its administration since 2000. The current structure of China's higher agricultural education mainly includes

Table 1. List of agro-related undergraduate education institutions in China 2014†

Universities	Model	Administrator	Project 211	Project 985
China Agricultural University	A	E	+	+
Northwest A&F University	A	E	+	+
China Ocean University	S	E	+	+
Nanjing Agricultural University	S	E	+	
Beijing Forestry University	S	E	+	
Huazhong Agricultural University	S	E	+	
Northeast Forestry University	S	E	+	
Sichuan Agricultural University	A	P	+	
Northeast Agricultural University	A	P	+	
Shanghai Ocean University	S	P		
Anhui Agricultural University	S	P		
Southwest Forestry University	S	P		
Qingdao Agricultural University	S	P		
Beijing University of Agriculture	S	P		
Shenyang Agricultural University	S	P		
South China Agricultural University	S	P		
Heilongjiang Bayi Agricultural University	S	P		
XinYang College Of Agriculture And Forestry	S	P		
Shandong Agriculture And Engineering University	S	P		
Zhongkai University of Agriculture and Engineering	S	P		
Xinjiang Agricultural University	S	P		
Yunnan Agricultural University	S	P		
Dalian Ocean University	S	P		
Zhejiang A&F University	S	P		
Jilin Agricultural University	S	P		
Nanjing Forestry University	S	P		
Gansu Agricultural University	S	P		
Henan Agricultural University	S	P		
Hunan Agricultural University	S	P		
Shanxi Agricultural University	S	P		
Jiangxi Agricultural University	S	P		
Jilin Agricultural Science and Technology College	A	P		
Zhejiang Ocean University	A	P		
Hebei Agricultural University	A	P		
Tianjin Agricultural University	A	P		
Guangdong Ocean University	A	P		
Shandong Agricultural University	A	P		
Inner Mongolia Agricultural University	A	P		
Fujian Agriculture and Forestry University	A	P		
Central South University of Forestry and Technology	A	P		
Henan University of Animal Husbandry and Economy	A	P		

† Notes: "A" means institution has adopted model A (Agro-related universities merged) and "S" model S (Self-development university without merging); "E" means institution that is currently under the administration of the Ministry of Education; and "P" under the provincial government; "+" means the institution has been granted a "Project 211" or /and a "Project 985".

(Data Source: Data retrieved on May 5, 2015 from introductions/about, official websites of above-listed universities).

two administrative models: universities managed either by central government or by provincial governments. Among them, nine agro-universities including China Agricultural University and Nanjing Agricultural University were transferred to and governed by the Ministry of Education. Eight other agricultural universities, including Shenyang Agricultural University, South China Agricultural University, etc. were shifted into and governed by the provincial/local governments.

After the reformation of the administrative system, many measures have been taken to boost China's agriculture through science & technology, education, and training. For instance, both the Ministry of Education and the Ministry of Agriculture signed the Agreement on Cooperation with Jointly Construct China Agricultural University and Seven Other Universities on May 27th 2009. Based on this agreement, the following 8 universities benefited from the two administrations backing up: China Agricultural University, Northwest A&F University, Nanjing Agricultural University, Huazhong Agricultural University, Southwest University, Jilin University, Shanghai Jiaotong University, and Zhejiang University. On June 4th 2010, the two Ministries jointly launched six measures for this purpose: (i) establish new cooperative mechanisms between agricultural and educational systems to build a group of agricultural colleges; (ii) encourage joint research projects and joint education programs at doctoral level between agricultural universities and related research institutions; (iii) set up a number of regional scientific and technological innovation demonstration centers for modern agricultural education; (iv) improve agro-disciplines, strengthen 23 innovative centers and 188 featured specialties for talent training, and transform 970 agricultural experiment stations into cooperative research and education centers; (v) extend the higher education in agricultural sciences to communities and individual farmers, and design tailor-made training programs according to the specific demand of communities and villages; and (vi) increase the policy support to key programs and speed up the pace to build world-class agricultural universities.

Up to now, there are three kinds of higher agro-education institutions in China, i.e. agricultural universities managed directly by the ministry of education, universities under the supervision of provincial or local governments and agro-faculty/college in comprehensive universities governed either by the ministry of education or by the provincial or local governments. The above structure not only fits the diversified conditions of China in rural regional differences, industrial and cropping structures, but also ensures the education and training of agricultural talents at all levels.

3. Granting to "Project 211" and "Project 985"

In almost all cases projects are initiated to create change –to develop new products, establish new manufacturing processes, or create a new organization. Without projects, organizations would become obsolete and irrelevant, and unable to cope with today's competitive business environment (Shenhar *et al*., 2001). In the 1990s, "Project 211" was launched by China's government, a project to build about 100 key universities and a group of key disciplines for the 21st century. It is a significant initiative to improve the development of higher education in order to catch up with the development of national economy and the society. This project is aimed to provide high-level research, high-quality talents for the strategic development of China, and has substantially contributed to improving the competence of China's higher education, speeding up the growth of China's economy, and promoting the development of science and technology. It also enhances the comprehensive national strength and international competitiveness of China and helps to achieve the mission of educating most of our top talents in China's universities. Nine agro-universities including China Agricultural University, Nanjing Agricultural University, etc. have been selected for "Project 211" since 1995 (See Table 1).

Later in the 1990s, China's government initiated the "Project 985", which was intended to construct a list of world-class universities and a group of world-renowned high-level research universities through setting up new management systems and operative mechanisms and catch up with the strategic opportunities in the first 20 years of the 21st century. By centralizing the resources to highlight advantages and distinctions of China's higher education, China intends to build world-class universities with its characteristics. Ever since 1998, altogether 39 universities have been granted to participate in this project, 3 of which are agro-universities: China Agricultural University, Northwest A&F University, and China Ocean University (See Table 1).

4. Implementing the Plan of Top Agro-forestry Talents' training

In order to deepen the reform of higher education in agricultural sciences and to enhance the capability of higher education institutions to serve the needs in ecological civilization, agricultural modernization and rural development, the China's Ministry of Education, Ministry of Agriculture, and the State Forestry Administration Department jointly issued the Suggestions on Promoting the Comprehensive Reform of Higher Education in Agriculture and Forestry and the Suggestions on Implementing the Education and Training Plan of Top Agro-forestry Talents in November 2013. The objectives of this Plan are: firstly, to form a multi-level and diversified training system in agricultural sciences and a number of agro-disciplines with China's characteristics through innovating management systems and improving the ability of professional education and social service; secondly, to promote and demonstrate the innovation in talent training through improving 200 pilot projects for training top innovative talents, interdisciplinary professionals and skill-oriented professionals; thirdly, to focus on practical teaching through implementing 500 talent training centers of education and research in agriculture; fourthly, to build a stronger faculty team through the selection and employment of 1,000 teachers who are both capable of theoretical and practical teaching in order to improve the overall competence of talent training in the higher education of agricultural sciences.

In September 2014, the China's Ministry of Education, Ministry of Agriculture and State Forestry Administration Department determined the first 99 pilot universities and 140 pilot programs of the Education and Training Project of Top Agro-forestry Talents. 43 programs are devoted to training top innovative talents, 70 are devoted to training interdisciplinary professionals, and the rest 27 are for skill-oriented professionals. The Project is playing an important role in enhancing the comprehensive reform of higher education in agricultural sciences and improving the capability of professionals, and also provides new opportunities for the development of China's higher education in agriculture and forestry.

5. Optimizing the structure of agro-higher education

Structures of higher education systems or more precisely, the shape and the size of the national higher education systems have been among the issues of higher education policy in the economically advanced countries of the world which absorbed enormous attention for more than four decades (Teichler, 2006). Great changes have taken place in the structure of China's higher education in agricultural sciences under the national guidance on the direction of stabilizing the development of undergraduate education, giving priority to the development of postgraduate education and developing professional education properly. The postgraduate education has achieved great development, whereas the undergraduate and professional education has experienced stable growth. The ratio of postgraduates, undergraduates, and professional students has been optimized and is now comparatively stable. In 1992, the total enrollment of postgraduate, undergraduate and professional students of China's agricultural universities was 124,567, including 3.1% graduate students, 64.5% undergraduates, and 32.4% of professional program students. In 2013, the total enrollment increased to 490,533, roughly four times 20 years ago, including 12.4% postgraduates, 53.0% undergraduates, and 34.6% professional students. Compared with 1992, there is a notable increase in the percentage of postgraduate students, which meets with the pressing demand of the society for agro-postgraduates (See Fig. 1).

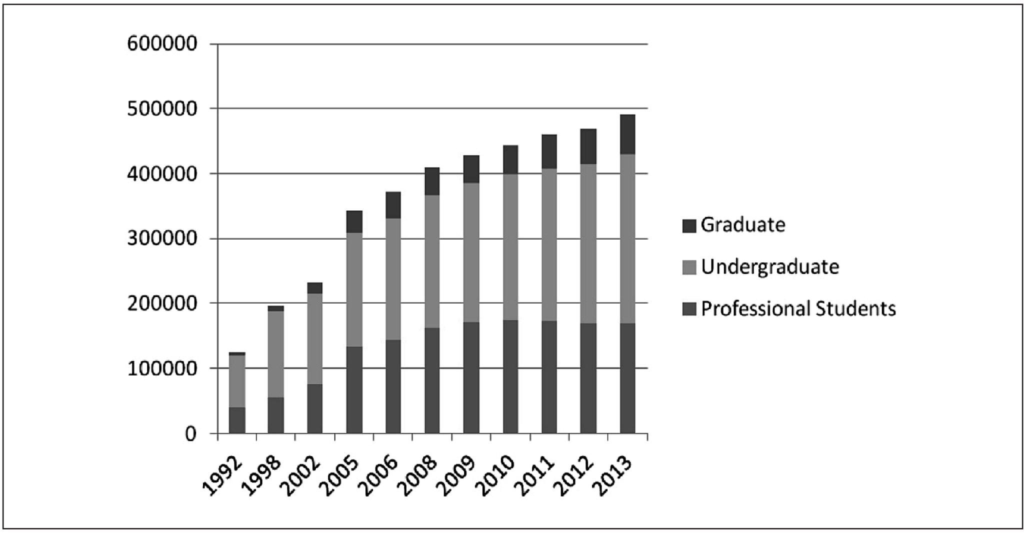

Fig. 1. Student's enrollment of China's agricultural universities from 1992 to 2013.

Source: Ministry of Education of People's Republic of China. Educational Statistic Data, retrieved on May 1st 2015 from: *http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/s8492/index.html*

It makes sense that through more than 20 years' development, the China's higher education in agricultural sciences is much more reasonable, with graduate education as its driving force, undergraduate education as essence, and professional education as implementation.

6. Establishing World-class Agro-universities

As a general rule, universities easily strive to attain top positions in their regions, countries or the world. Most of them have aligned their mission statements and objectives to those of world-class universities in the respective teaching and research areas (Lepori, 2007). As China is getting more and more involved in the world, China's higher agro-education institutions administrators begin to review their missions and visions from a global perspective in order to make greater contributions to human and social development. "Building World-class Agro-universities" is proposed and originated as the strategic objectives of some agro-universities. World-class Agro-universities represents World-class Universities with certain characteristics, which will be demonstrated by offering world-leading agro-education and research programs, hosting world-class researchers, teachers and students (both undergraduates and postgraduates) in agro-sciences; achieving world-class influences in agricultural production and related practical areas, and providing knowledge, technologies and talents for the agricultural development of the region, the country and the world.

On May 2, 2009, when the former President Hu Jintao of P.R.C visited China Agricultural University, he proposed a statement of "speeding up the pace of constructing World-class Agricultural Universities". This decision encouraged all the faculty and students from agro-universities. In the same year, China Agricultural University defined the specific objectives for establishing a World-class Agricultural University. In July 2011, Nanjing Agricultural University (NAU) also set up the objective of achieving to be a "World-class Agricultural University", and in September 2011, the university officially declared the strategic objective of achieving "World-class Agricultural University" and the related development requirements into NAU 12th Five-year Development Plan. In February 2012, the Decision on Accelerating NAU's Construction of a World-Class Agricultural University was issued. Since then, most of China's leading agro-universities have their development strategies more focused on building world-class faculty team, achieving world-impact scientific research outcomes, cultivating leading talents and formulating a diversified campus culture.

Through the above measures, China's higher agro-education has achieved marvelous accomplishments in over the past 20 years. According to a recent ranking by US NEWS (Best Global Universities for Agricultural Sciences), four China's universities rank top 100 in the world: China Agricultural University (4), Nanjing Agricultural University (36), Huazhong Agricultural University (67), and Northwest A&F University (97), which are also ranked number 1, 3, 12 and 17 in Asia region respectively (U.S. News, 2014).

In addition, the QS World University Rankings by Subject 2015 (Agriculture and Forestry) ranks China Agricultural University as no.18 and three other universities (Beijing Forestry University, Nanjing Agricultural University Northwest A&F University) 50-100,respectively(QS, 2015).

From the NTU Ranking System (TOP 300 in Agricultural Field) from 2009 to 2014, it is easy to find out that three China's agricultural universities have made great progress in the recent years (See Fig. 2).

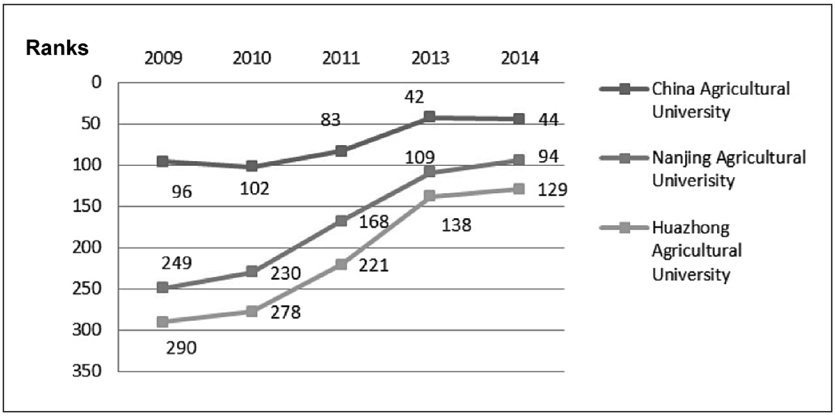

Fig. 2. Ranks of China's three agro-universities in NTU Ranking System (TOP 300 in Agricultural Field) from 2009 to 2014.

Data Source: Data retrieved on May 5, 2015 from Rankings by Field (Agriculture) in 2009-2014, National Taiwan University Ranking (NTU Ranking).
<http://nturanking.lis.ntu.edu.tw/DataPage/TOP300.aspx?query=Agriculture&y=2009>;
<http://nturanking.lis.ntu.edu.tw/DataPage/TOP300.aspx?query=Agriculture&y=2010>;
<http://nturanking.lis.ntu.edu.tw/DataPage/TOP300.aspx?query=Agriculture&y=2011>;
<http://nturanking.lis.ntu.edu.tw/DataPage/TOP300.aspx?query=Agriculture&y=2013>;
<http://nturanking.lis.ntu.edu.tw/DataPage/TOP300.aspx?query=Agriculture&y=2014>.
*Note: According to the NTU Ranking website, the ranking data in 2012 and 2010 are very much the same. In the Figure, data in 2012 have been omitted supposing they have been duplicated from 2010.

Nevertheless, to be a World-class University in Agricultural Sciences, achieving top 1% of global rankings on agro-subject areas (top 20) and top 1% of global rankings for universities (top 500) is necessary (Liu *et al*., 2015). It can be easily found that great gaps are still remaining between China's first-rate agricultural universities and those of world's famous comprehensive universities specialized in agricultural sciences, such as UC-Davis, Cornell University, Wageningen University, UCB, Texas A&M University, Swedish University of Agricultural Sciences etc. There is a long way to go for the dream of China's World-class Agricultural University.

III – Challenges to confront

Nowadays, globalization widely exists in the economy, society, education and many other aspects. It calls for interdisciplinary researchers with more international communications and collaborations in order to cope with climate change, food security, human sustainable development and other world key issues. Under the new circumstances, every agro-university in China confronts the following challenges:

First of all, how to keep the balance between characteristics and comprehensiveness in university's development strategies? Comprehensive development is a fundamental requirement for higher education as a whole, while agro-disciplines represent the distinctiveness and basis of higher education in agricultural sciences. In the ideal organization, management would be equally adept at performing two somewhat conflicting functions: it would be able to create an administrative system (structure and processes) that could smoothly direct and monitor the organization's current activities without, at the same time, allowing the system to become so ingrained that future innovation activities are jeopardized. Such a perspective requires the administrative system to be viewed as both a lagging and leading variable in the process of adaptation (Miles *et al.*,1978). Therefore, the comprehensive development strategy of an agro-university should be guided by and in accordance with featured strategies on distinctiveness. In other words, the further development of a university should be breakthroughs in specific academic fields. Since 2011, Nanjing Agricultural University has integrated its 19 colleges into 5 academic groups in order to promote interdisciplinary collaborations.

Secondly, how to promote the internationalization of China's agro-universities? Currently, global higher education institutions are inevitably involved in the intense competition. It is compulsory for China's higher agro-educational institutions to push forward internationalization process with great passion and dedication. Internationalization has a positive impact on promoting academic communications, elevating education level, strengthening competitiveness, enriching the students' learning experience, increasing competitive advantages and enhancing the reputation of the university at a global level. The internationalization of China's higher agro-education institutions kicked off relatively late, with existing problems such as smaller scale, incomplete education structure, limited foreign language level of both teaching faculties and students, lower diversity in the country origins of international students, inflexible management model of international students, limited funding sources other than the government, less attractive featured courses, and low international reputation of universities.

Recruiting teachers with international background, expanding the enrollment of international students from more countries, offering more courses in English, acquiring more international evaluation and recognition of disciplines, and setting up international collaborative research centers and technology transfer centers have become common practices among many agricultural universities of China. Based on their international collaboration status, different agro-universities have launched various kinds of international activities. In order to promote the communication and collaboration in agricultural education, and to carry out the research on African agriculture while promoting agricultural technologies, Nanjing Agricultural University and Egerton University have jointly launched world's first Agricultural Confucius Institute in Kenya. Nanjing Agricultural University has also strengthened the collaborations with international organizations through initiating GCHERA World Agriculture Prize and hosting the "World Dialogue on Agricultural and Life

Science Education and Innovation". Northwest A&F University has started the annual session of "Yangling International Agro-science Forum". Through the establishment of international colleges. China Agricultural University, Huazhong Agricultural University etc. have carried out various forms of collaborations, such as joint degree programs with universities in Europe, the United States, Canada and other countries and regions.

Thirdly, how do we meet the social needs given rise to the modern agriculture? Modern agriculture signifies itself by widely applying modern technologies. It utilizes all means of production provided by modern industry and scientific management approaches and is supported by socialized service systems and nice ecological environments. The development of modern agriculture depends on the dissemination of the environmental-friendly concept, the advances in technologies as well as the contribution of well-trained professionals. Higher education institutions in agricultural sciences are expected to redefine their missions in order to educate more outstanding professionals in related fields and promoting new multidisciplinary collaborations in agricultural science, in order to contribute to the further development of modern agriculture. Both Henan Agricultural University and Hunan Agricultural University have separately led the establishment of national collaborative innovation centers of food crops and oil crops with agricultural research institutions and industrial organizations, which provide intellectual support for national food security. Professors from agro-universities have become the think tank for the government in coping with climate change, food security and sustainable development issues. Supported by "Program of New Rural Development Institutes", "Program of Outstanding Talents in Agriculture and Forestry" and other domestic projects, China's agro-universities have been working on establishing classified cultivation of talents, promoting the integration of different subjects, and providing talents for serving rural areas, farmers and agriculture.

IV – Conclusions

From the above discussion, the following conclusions can be drawn:

In the past twenty years, a lot of measures have been undertaken in driving the development of China's higher agro-education, such as modification of developing models from the unique agricultural institution specialized in one broad field to a comprehensive one with a wide range of subjects either by merging or self-development; reformation of administrative system from specific sector to ministry of education or provincial administration; granting to Project "211" (nine agro-universities granted) or/and Project "985"(three agro-universities granted); implementing the Plan of Top Agro-forestry Talents' Training and optimizing the structure of agro-higher education to satisfy the social needs; encouraging some domestic top-agro universities to establish world-class universities in agro-science. A preliminary achievement has been made: three China's agricultural universities' ranks keep rising in the recent years while they started their destinations as World-class Agro-universities, but a large gap still remains as compared with their counterparts in other countries. Under the new situation, China's agro-universities confront many new challenges they have to cope with: balance of characteristics and comprehensiveness, internationalization and meeting the social needs, etc. Initiative transformative models have been adopted to cope with the uprising problems, such as university institutional reorganizing, setting up overseas joint institutions or programs, as the said Agricultural Confucius Institute, establishment of national collaborative innovation centers for agriculture, the Program of New Rural Development Institutes etc.

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Joint degrees: the future for agricultural higher education in the EU?

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Abstract. In this article, the example of the International Master of Rural Development (IMRD) is used to show how joint master degrees can be and are a tool to foster international cooperation between Higher Educational Institutes (HEIs) in the area of education. First potential models for joitn degrees are defined, next the development of the IMRD course is presented as well as the challenges posed by joint degrees and how they can be overcome.

Keywords. Joint degrees – Higher education – Rural development.

Filières de formation conjointes : l'avenir de l'enseignement supérieur agricole au sein de l'UE ?

Résumé. *Dans cet article est présenté l'exemple du Master International en Développement Rural (IMRD) afin de montrer comment des formations conjointes de Master peuvent être et sont des outils pour favoriser la coopération internationale entre Instituts d'Enseignement Supérieur dans le domaine de l'éducation. Les premiers modèles potentiels pour des grades conjoints sont définis, ensuite sont présentés le déroulement du cours IMRD ainsi que les défis posés par les grades conjoints et comment les surmonter.*

Mots-clés. *Grades conjoints – Enseignement supérieur – Développement rural.*

I – Introduction

Double, multiple and joint degrees are promoted as an opportunity for international higher education cooperation. The International Master in Rural Development (IMRD) existing since 2004 is an example of such a joint master. By presenting the development of this master we illustrate the possibilities and challenges of joint masters. We argue that joint masters do indeed provide a high potential to train future specialists in agricultural and live sciences, in particular for international functions which become more and more common in a globalized world. The main advantage is that students get training from the best specialists in a discipline if the master is well constructed and get acquainted with different circumstances of agriculture and rural development. Due to the mobility requirements students are also obtaining those communicative and transferable skills required for international functions.

Of course joint degrees are not limited to master programs. In theory they can also be developed for undergraduate or bachelor programs and certainly are often applied for PhD degrees. However in practice, when discussing joint degrees mostly the graduate or master level is concerned. At undergraduate level at least in the EU, there is often a language barrier (unless the study of languages is concerned) and legislation allows less flexibility in terms of learning outcomes or courses to be followed. At PhD level double or joint degrees do not pose the same challenge as mostly university regulations allow to make contracts at an individual student level meaning that for each student separately a different 'construction' can be set up (specifying the individual program, the thesis and defence requirements and so on). This of course allows a lot of flexibility and so these days a lot of joint PhD programs exist. Joint masters (and bachelors), however, do pose more challenges because they cannot be individually tailored but require a serious effort of defining common learning outcomes, entrance criteria, programmes and quality control systems. Joint masters have been promoted in Europe mainly under the Erasmus Mundus program. Different models are however possible.

In this article we mainly look at joint master programs. In section 2, we describe potential models and argue why we have developed the particular model used for IMRD. In section 3, we describe how IMRD is created and organised, and provide some data on its development since 2004. In section 4 some challenges are described and how they need and can be overcome. Finally we conclude in the discussion and conclusion section with some general remarks and recommendations for the further promotion, development and accreditation of joint masters programs.

II – Models for joint degrees

In discussing joint degrees there is a lot of confusion in terminology and the term joint degrees is often misused for situations where there is only credit exchange or where students only receive a degree from those universities where they have followed a substantial part of their curriculum. In general it concerns degrees in which students have studied in at least two different universities (mostly) belonging to a same consortium who have made a contract and have set forward the conditions under which students receive a particular degree. We make following distinction in definitions:

1. Single degree with curriculum exchange: this is the situation in which the student receives a degree of one single university but is allowed (or even pushed or obliged) to take courses in one (or sometimes more) partner university(es). These courses are mentioned in the diploma supplement, however without leading to a mentioning of the name of the other university on the diploma. So the student has only one diploma or degree which is only recognised and accredited in the country in which the university is situated. Formally these are not joint or multiple degrees but the student can at least indicate that he has studied in one or more other universities. Most universities apply this model for the student exchange contracts.

2. Double degrees: this is the situation in which the student follows a substantial part of his curriculum in (at least) two universities and receives two single diplomas signed separately by each of the universities. Often the student receives one certificate and diploma supplement mentioning his total curriculum and under which conditions the degree of the university is combined with the degree of the other university. So in the end the student has two diplomas or degrees with the advantage that each degree is separately recognised and accredited in the respective countries of origin. An example is the IMRD-Arkansas double degree (see further) but a lot of other examples exist.

3. Multiple degrees: this is the same situation as above but in a system where there are more than two partners in the consortium. In this situation, the student gets two or, in particular cases or specified conditions, three or exceptionally more degrees from those universities of the consortium where he has followed a substantial part of his studies. This may result in situations that students who have studied in the same consortium of universities receive different degrees (e.g. student 1 receives the degrees of university 1 and 2, student 2 of university 1 and 3 and student 3 of university 2 and 3 depending on where each students has exactly studied). Also in this situation the degrees are mostly accompanied with an overarching document describing under which conditions which degrees are or can be obtained. So in both double or multiple degrees each separated university decides whether and under which conditions students receive its degree (e.g. in terms of admittance, number of credits to be taken at the university itself, conditions on the credits obtained in the partner universities…).

Joint degrees: real joint degrees are situations in which students are studying in a consortium of universities and can follow courses according to the rules of the consortium in the different partner universities but receives one single common degree undersigned by the different consortium partners (regardless of whether the student has been studying and obtained credits at the partner itself). An example of such degree is the IMRD degree. In this situation the consortium decides on common criteria in terms of admittance, program and other conditions and sets up a common system of quality control and student monitoring. The joint degree is recognised and accredited in at least one partner country but in most cases in each of the partner countries (see also further).

We think that the last system has a number of advantages and is also the model promoted by the EU. The reason why we have opted with IMRD for this system is that one single degree is created which has major advantages in terms of promotion and visibility for the employers. It also emphasizes that there exist a common framework and learning outcomes which have been obtained by all students because behind the degree there is one single set of objectives and outcomes. Further it allows to create larger consortia because it does not require that each single students has been in each of the partner universities and it creates also possibilities to combine the single joint degrees with the other models (credit exchange contract with occasional partners) or double degree contracts with partners who do not belong to the core consortium but with whom students are frequently exchanged (as is the case for the IMRD ATLANTIS or EKAFREE degree, see further).

Within the joint (or also double or multiple) degree model, still different operational models are possible. One mode of operations is that each consortium partner institutes offers more or less the same curriculum (or learning outcomes) and students can freely (or under specified conditions) opt in which universities they follow each separated building block of the curriculum (mostly organised per semester). In this mode of operations different students of the same batch/cohort do not necessarily encounter each other (unless some common study activities are foreseen or obligatory, e.g., a common summer school between semesters or years). A second mode of operation quite often applied within Erasmus Mundus (EM) courses is that each university (or in a few cases more than one university) offers one of the building blocks of the common program and students of the same batch switch together over the building blocks or have a limited choice where they can follow each module (except for the thesis semester). This model is mostly adopted by consortia with a limited number of partners (3 to 5). Larger consortia like IMRD[1] either opt for mode 1 or for an operational mode in which one (or a limited number of) partner(s) offer the basic module, after which students can (under specified conditions) select modules in the different partner institutes. It is this last model that IMRD has adopted as is described in the next section. In this last operational mode, consortia try to combine the advantages (both in terms of intake as in terms of common learning outcomes) of operational mode 2 with the flexibility and choice possibilities for students of operational mode 1.

III – The IMRD history and model

1. IMRD development

As already indicated in the introduction the IMRD course and degree is a 2 year master programme which has been created in 2004 at the start of the Erasmus Mundus Master program developed by the EU. However, the course did not came out of the blue as the core consortium partners were already cooperating for many years in student exchange, research and in particular the organisation of so called ‘intensive course programs’ (also financed by EU). Intensive course programs (IPs) were short courses (normally 2 to 3 weeks) organised by one of the con-

[1] The IMRD Consortium currently consists of 16 partner universities.

sortium members in which teachers and students of the different partner universities were brought together to study together a particular problem or topic. The IMRD consortium partners had already a tradition of about 10 years to yearly organise a particular IP on rural development issues. The particularity of their model was that each year the problem of multifunctional agriculture or rural development was studied in a particular case study in one of the consortium partners. This resulted even in a book (Van Huylenbroeck and Durand, 2003) that has highly influenced the modern thinking on integrated rural development in Europe. Further the same (or at least the core) partners had worked together in an exchange program with some Brazilian universities and so also build up some expertise in teaching the EU rural development model to non-EU students.

So when in 2004 the first EM master courses call was launched by the EU, the IMRD consortium was in a good position to apply for the organisation of such an EM course. The consortium was directly successful in the first call and the first IMRD students' batch started off in October, 2004.

The consortium started off at that moment with 7 universities, consisting of 4 core partners (Ghent University (BE), Agrocampus Rennes (later Agrocampus Ouest) (FR), Humboldt University of Berlin (GE) and UCO (University of Cordoba (ES)) who agreed to award and sign the joint degree and three universities (Slovak University of Agriculture in Nitra (SK); University of Pisa (IT) and Wageningen University (NE) who for legal reasons could not (yet) sign the joint degree (at least not under the definition as given in section 1). We must admit that due to the short preparation time and lack of experience the learning outcomes and course program at that moment were loosely defined. The program was a five modules programme consisting of four semesters and one summer case study. Students could start at each of the four core partner institutes, take semester 2 and 3 in each of the 7 universities on condition that they could follow courses in the national language (or English for Gent and Berlin), follow the only fixed module, being one of the two organised case studies (Nitra or Pisa), and defended their master thesis in one of the four core partner institutes. The courses students could select were all the courses given in social sciences in each of the partner institutes, and besides the obligatory case study the only other obligation was to study in at least two partner institutes other than the partner in which they had followed the case study. So the course was loosely defined and no real common learning outcomes recorded. There was a common selection of students and for quality monitoring reasons also an obligation that in the examination board of the master thesis at least one professor should be present of a partner university different than the one where the defence takes place The two weeks case study module (5 ECTS) was made obligatory because of the strong positive experience with the IPs organised before, and the wish of all partners that students should also obtain some practical and applicative skills besides the academic competences.

The first three years (cohorts) IMRD was organised under these conditions. It allowed the partners to know each other's program better and to experience the strong and weaker points of the selected organisation. The weakest point (also acknowledged by students) was that students did not know each other as the only time they really met (at least half of the batch) was during the two weeks case study besides being occasionally together in a same university for one semester. But even when they studied at the same university, this did not mean that they were following the same courses as the selection of courses was completely free. Therefore from the fourth batch on (starting in academic year 2008) we better defined the learning outcomes[2] and obliged students to follow the same introductory semester module (organised by Ghent University). Further we also defined better the semester modules organised by the each partner (focussing on the strong research points of each partner) in order to increase the academic quality. Alongside the case study was enlarged from 2 weeks to 1 month (10 ECTS) in order to increase the

[2] See http://www.imrd.ugent.be/index.asp?p=2055&a=61

acquaintance of applicative skills. Also, and due to the existing possibility (and even strong requirement) to increase the consortium with non-EU country partners, the consortium was gradually increased with partners from South America (ESPOL, Ecuador), South Africa (University of Pretoria), India (University of Agricultural Science, Bangalore), and China (China Agricultural University and Nanjing Agricultural University). The idea behind this enlargement was to foster more on the comparative study between different rural development models and agricultural policies and to allow also EU students to get better acquainted with non-EU rural situations. To allow this, the programme has from 2008 been structured as visualised in Fig. 1.

<table>
<tr><td rowspan="4">1st
YEAR
IMRD</td><td colspan="5">GENERAL ENTRANCE MODULE 25-35 ECTS
Ghent University</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">ADVANCED MODULE I 15-40 ECTS</td></tr>
<tr><td colspan="2">Rural Economics and Management
Ghent University</td><td colspan="2">Institutional and Resource Economics
Humboldt University</td><td>Non-European Partner University</td></tr>
<tr><td colspan="6">It is not possible to choose HUB in sem 2 AND 3, only one advanced module can be taken at HUB</td></tr>
<tr><td rowspan="7">2nd
YEAR
IMRD</td><td colspan="5">CASE STUDY 10 ECTS</td></tr>
<tr><td colspan="5">Slovak University of Agriculture or Pisa University</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">ADVANCED MODULE II 15-40 ECTS</td></tr>
<tr><td>Sustainable Agriculture and Rural Development
Agrocampus Ouest</td><td colspan="2">Rural Sociology and Development
Wageningen University</td><td>Institutional and Resource Economics
Humboldt University</td><td>Non-European Partner University</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">MASTER THESIS 30 ECTS
One of the previously visited European host Institutions</td></tr>
</table>

Fig. 1. IMRD Mobility Scheme 2008-2014.

From 2008, the course program was thus more targeted and also better streamlined, facilitating a lot the intake and monitoring of students, the quality control and the overall administration. Because the main objective shifted from studying the EU rural development policy towards comparative study of worldwide agricultural rural development objectives, challenges and policies, we also enlarged the consortium with (originally two, later only one) US partners when the occasion was presented to apply for the so called Atlantis program. This was done in a double degree construction because for this program the requirement was that students should study at least for 8 months or 40 ECTS at either side of the Atlantic. At that moment, the strong flexibility of the IMRD construction became eminent. By having a single degree at EU side (and not the multiple degree construction of most other so called joint degree programs under EM) we were able to flexibly enter the Atlantis program by simply matching the EU IMRD degree with the US degrees of Arkansas University as well as originally also of Florida University. This last partner did not want to continue its engagement when the funding stopped in 2013 for the Atlantis program (while Arkansas University did, and entered the IMRD consortium). In the meantime also UCO, for particular reasons, decided to leave the consortium. In 2013 we welcomed a Vietnamese University in our consortium (Can Tho University; more specifically its Mekong Delta Research Institute) as it was our desire (after earlier good experiences in China) to organize (in particular for the EU students) a case study outside the EU. In 2014 we were also successful in setting up a similar construction as in the Atlantis case with three universities in South Korea, called the EKAFREE degree[3]. This brings the present number of partners at 16 with 6 at EU side, 6 non-EU partners in IMRD, 1 ATLANTIS partner and 3 South Korean universities[4].

The IMRD program also passed successfully 3 accreditation exercises (two by EAALS (ICA) and one by the VLUHR (Flanders) as well as the EU (EACEA) Quality Review in 2014, who gave the consortium access to the Erasmus+ financing under the Erasmus Mundus Joint Master Degrees Action. Because of the enlargement of the consortium, we slightly modified our program starting from the 2015-2016 intake on by adding the requirement that students should be inscribed for the last two semesters (thus for the whole second year) at the institute where they will work on and defend their thesis. This extra requirement is also installed to guarantee that students are well supervised during their thesis year, and follow courses related to their dissertation topic. Of course students can still go for field work for their thesis to another country or university. Hence the present structure of IMRD is as follows (Fig. 2).

1st year IMRD	**GENERAL ENTRANCE MODULE** SEMESTER I 30 -35 ECTS
	Ghent University
	ADVANCED MODULE I SEMESTER II 15-40 ECTS
	Any partner university different from thesis partner university
2nd year IMRD	**CASE STUDY** SUMMER COURSE 10 ECTS
	University of Pisa or Slovak University of Agriculture
	ADVANCED MODULE II SEMESTER III 15-40 ECTS
	Thesis partner university
	MASTER DISSERTATION SEMESTER IV 30 ECTS
	Thesis partner university

Fig. 2. IMRD Mobility Scheme starting academic year 2015-2016.

2. IMRD figures

The above development and model proved to be successful, flexible and strongly appealing for top students worldwide. The success can be seen both in terms of applications and enrolled number of students (as well as in terms of student comments during and after their studies. Since 2004, the IMRD programmes has welcomed students from over 67 different countries, and although the amount of EM scholarships was decreasing on a yearly base, the number of starting students roughly remained equal, but the numbers of strongly interested applicants starting the application process increased on a yearly basis (Table 1).

[3] EU-Korea Agricultural, Food and Resource Economics Experts Building Project. The Korean partners are Korea University, Seoul National University, Chungbuk National University.
[4] Since 2008 all EU partners have become core partners and are signing the joint degree diploma. All except Wageningen University due to a conflict with national law regulations; and who consequently does not participate in the ATLANTIS and EKAFREE double degree constructions.

Table 1. Application and student numbers IMRD by session

Cohorte (years)	Number of applicants			Number of admissions		
	Total	Female	Male	Total	Female	Male
Session (13-15)	(676) **364**	95	269	(268) **30**	(67)**19**	(201)**11**
Session (12-14)	(1213) **432**	117	315	(244) **21**	(67)**16**	(177)**5**
Session (11-13)	(557) **377**	81	296	(104) **18**	(32) **9**	(71) **9**
Session (10-12)	(461) **337**	76	261	(184) **21**	(43) 11	(141) **10**
Session (9-11)	(361) **305**	82	223	(106) **20**	(29) **9**	(77) **11**
Session (8-10)	403	103	300	(161) **33**	(45) **15**	(116) **18**
Session (7-9)	411	115	296	(129) **36**	(48) **16**	(81) **17**
Session (6-8)	374	109	265	(129) **45**	(48) **22**	(81) **19**
Session (5-7)	238	82	156	(129) **35**	(48) **20**	(81) **15**
Session (4-6)	n/a	n/a	n/a	12	**5**	**7**

Note: (Application incomplete) **complete.**

Note: (Academically accepted) **started the course.**

The success and quality of the program itself also becomes apparent in the positions of our alumni and the number afterwards selected for a PhD or who are working for high level (inter)national organisations (Fig. 3).

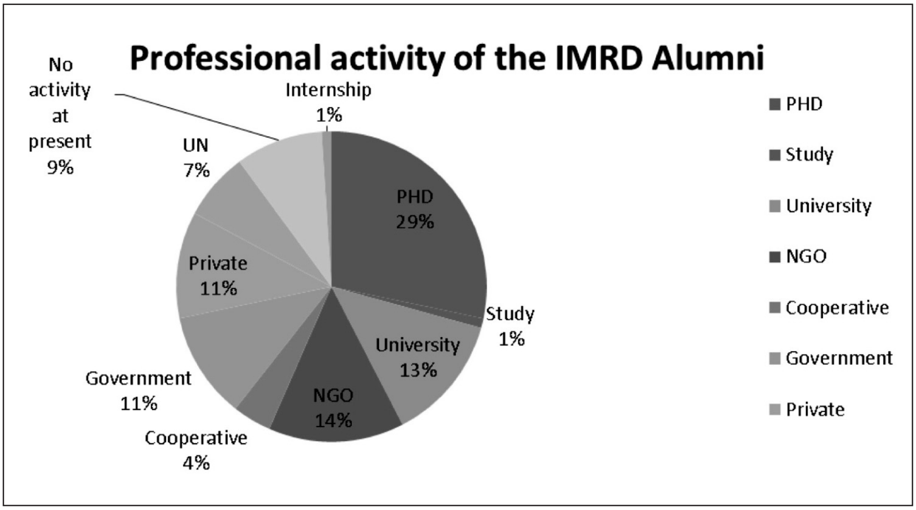

Fig. 3. Professional activities of IMRD students (Alumni survey – 2011 (100 respondents)).

IV – Challenges

Setting up and running joint master degree programs poses a lot of challenges which we can divide in following categories:

1. International student intake and mobility requirements.
2. Harmonising rules of different partner institutes and quality monitoring.

3. The changing course curriculum at the partners.

4. Centralised follow-up of “on the road” students.

5. Sustainability and the creation of a lively alumni network.

Challenge 1 has to do with the international student population that is aimed for. As such this is a real strength and asset for the program as within an international student community, students learn a lot of each other. Besides the academic information, the personal skills of students are challenged and improved by the contacts they have among each other inside and outside the classroom. Of course it requires a whole organisation to attract the students from different countries both in terms of making publicity for the degree program, the evaluation of prospective students due to different study standards in different countries, visa and entry problems (exemplified due to the high mobility requirements and the lack of a harmonised European visa policy) and of course also different expectations and study habits due to different study systems over the world, intensified by the fact that in general IMRD students are older than students in regular programs. The mobility stipulations also require a lot from students as they cannot easily settle in one country. This poses problems like finding housing for only a few months, applying each time for visa, a lot of monitoring on their progress, not always easy communication between the central secretariat and students at different places.

But not only the international student community though also the international profile of the program poses challenges going from harmonisation of academic calendars (e.g., in IMRD the problem of the specific academic calendar of Germany which does not fit well with that of other partners), over different evaluation systems in the different partners (it took us more than 5 years to come to a non-contested conversion able of exam scores), to different rules and regulations and different learning culture. Therefore a lot of efforts have to be put in finding a balance between harmonising rules where required and flexibility where needed. A problem in this respect as compared with regular programs is the lack of enforcement power of the coordinating university on its partners e.g. in cases where there is a need for harmonising rules; or when a university decides to change the course curriculum of a faculty/department/study, and the offered courses (attached to learning outcomes) of the joint degree program are under threat In a lot of cases there is dependency on goodwill of partners to adapt their regulation or at least offer/provide the necessary flexibility within their own system. In order to tackle these challenges, it is imperative that the joint degree has a regulatory institution (within IMRD called the Management Board) which regularly meets and consists of representatives of all partners who openly discuss various issues and possible – out of the box – solutions. The factual cohesion of this institution will define the success of the joint degree. Fortunately, over the years trust is being built up, but still (e.g. in cases of changes of persons at the central level) this sometimes poses problems in particularly because also rules of the funding agencies may change (see the different rules of the EM program over the years).

This lack of authority in harmonising rules poses also particular problems in the setting up of a quality monitoring program, because for evaluations a joint degree program is of course bound by quality monitoring rules of the different institutions. Therefore in the quality monitoring process of IMRD we have put as first level the different institutional monitoring bodies in particular with respect to the individual courses as at that level it is very difficult to intervene from the program board level. The second level is then the overall program coherence and quality which is the level where the board can intervene. This requires a central monitoring instrument. IMRD has for this purpose developed an own quality monitoring tool in which students and alumni are at regular basis asked to give their opinion on the program, the different parts of the program and their coherence. This has proven to be very useful as an add-on to the individual institutional quality monitoring because it is only at program level that problems of overlap of courses, coherence in learning outcomes, balances in the evaluation systems, etc., can be detected. This system already induced several changes and adaptations of the curriculum. We made also extensive use of the quality monitoring tool that has been developed at EU level for international course programs (EMQA).

Joint programs pose also particular problems at the external quality control or accreditation level. The problem is here that when accredited by national agencies, these agencies have no or very limited experiences with programs that require extensive mobility and try to impose their national quality standards. But even when international accreditation agencies are used (like EAALS in the IMRD case), practice has shown that these agencies are not really familiar with the daily practice of joint degree programs and sometimes have difficulties understanding the challenges such programs pose in terms of quality monitoring and exerting authority on other institutes. Examples of these are a.o., the requirement of having one course catalogue there where in practice course catalogues of the different institutions have different rules or the inability of accreditation commissions to really understand (the rather complicated but good working) conversion table. Sometimes we had the impression that even these agencies which try to promote international educational cooperation are less cooperative than national accreditation agencies. A particular challenge in this respect is the recognition of joint master programs in still rather organised national labour markets. It remains e.g. difficult for IMRD to attract students from countries where the 'engineering' title is still protected or highly valued because the master programme, although embedded in institutions that offer regular (bioscience) engineering degrees, has not obtained the right to give an engineering tile to its alumni (due to particular legislation on this in the different countries).

Joint degree constructions furthermore come with a high administrative load as students are (constantly) on the move and need to be closely followed-up to guarantee they are aware of and respect the mobility and academic (i.e. obtain all set learning outcomes) requirements. Especially within large consortia like IMRD this is an intensive task. Within IMRD a Central Secretariat has been created for this purpose. With students often spread over various partners and continents (with different time zones) at the same time, written communication and the well-informing of the students becomes a major part of the program administration.

Finally, the most difficult challenge remains the sustainability of joint degree programs. The required mobility makes this kind of programs of course expensive in comparison with regular national programs, not only for students but also for the organizers. As long as support can be obtained from the EM program, the central secretariat costs can be recovered, but even then it remains a financial challenge to run the program. The rather high entrance fees often prove to be a barrier for national students, in particular because in a lot of countries studying is either for free (e.g., Germany) or fees are rather low as compared to what these joint programs need to ask (also because they are often not supported in the same way by the national educational subsidies). Most joint masters existing are also due to the EM policy oriented towards non-EU students posing the problem of dependency on scholarship programs as it is not so easy to attract good self sponsoring students (in particular in a global market that we are less familiar with than with our own national markets). Engineering and hard sciences programs may often join forces with sponsors of the private industry, but for soft (social) sciences these possibilities are extremely limited. In this sense a lively and active alumni network could be a major asset; not only as sources of possible – small – donations, though also as the group of lobbyist towards their employers and professional connections. The fact however that EM alumni come from many different countries, proves if very hard for an effective alumni organisations to be created that actually meets and delivers. IMRD has therefore set up an own scholarship program at least to match with the new requirements of the EM+ program. We hope that in this way the sustainability is increased but joint programs remain in general highly dependent on finding external scholarships for prospective students.

V – Discussion and conclusions

In this paper we have tried based on the IMRD experience to elaborate on the opportunities and challenges posed by joint degree programs in particular at master level. We think joint degree programs are an excellent tool for increasing cooperation among higher educational institutes. The reason is that in comparison with normal exchange programs, or even double or multiple degree programs, institutes are forced to think and act in a harmonised way. This makes that such programs are in general really programs of excellence because they can bring together not only the best knowledge of the different partner institutes, but also the best experience in terms of training and education. As joint degrees force the institutes to reflect on common learning outcomes, quality monitoring systems and so on regardless of national habits, a more international spirit is created. In the present educational world which is still highly dominated by national programs this poses of course a lot of difficulties; but the existing joint programs have not only already taken away some of the previous existing barriers (e.g., degrees signed by different institutes) but also lifted up the quality of education in a number of institutes by making the educational authorities of institutions involved into reflection of their own rules and standards. Therefore we advocate the further spread of joint degree programs and hope that they become the standard in future rather than the exception because it is clear that joint degree program alumni are much better trained to act in a globalized world than most of the national degree program alumni.

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Annex 1. IMRD learning outcomes

On a successful completion of the programme, students are due to their high level academic and multi-disciplinary training and multi-cultural experience, able to:	**Dublin descriptor 2nd cycle**	**EQF Level 7**	**CM-UGent**
1. Understand different socio-economic concepts, theories and multi-disciplinary approaches with respect to rural economies and rural development	Knowledge and understanding	Specialised knowledge and ability to apply and extend: advanced knowledge	CM 1
2. Have profound insights in different rural development realities, and be able to compare rural development issues, approaches and policies within an international context. Specific for the ATLANTIS track: comparison between rural economies and agricultural policies in EU/US	Knowledge and understanding	Specialised knowledge and ability to apply and extend: advanced knowledge	CM 1
3. Apply theories and methodological approaches to characterise and analyse the economic and social problems of rural areas, food and agricultural chains, natural resource management, national and international agriculture.	Knowledge and understanding	Specialised knowledge and ability to apply and extend: advanced knowledge	CM 1 + CM 2
4. Design and implement adequate instruments, methods, models and innovative tools to analyse, evaluate and to solve problems related to agriculture, food chain and natural resource-management, and to rural development and countryside stewardship	Apply knowledge and understanding	Specialised knowledge and ability to apply and extend: constructive and innovative use of standard methods	CM 1 + CM 2
5. Design, implement and monitor national and international agro-food policies, rural institutions and rural development programs	Apply knowledge and understanding	Specialised knowledge and ability to apply and extend: constructive and innovative use of standard methods	CM 1 + CM 2
6. Construct innovative tools and instruments for the (multifunctional) development of rural areas	Apply knowledge and understanding	Scientific competence: demonstrate creativity	CM 2 + CM 3
7. Design and assess research in the domain of rural development, formulating a problem statement and operationalizing objectives and research questions within an adequate research plan	Formulate judgments	Scientific competence: design research	CM 2
8. Select and apply appropriate research methods and techniques to collect and analyse data from literature and empirical research in the domain of rural development	Formulate judgments	Scientific competence: select and apply appropriate techniques	CM 2

On a successful completion of the programme, students are due to their high level academic and multi-disciplinary training and multi-cultural experience, able to:	**Dublin descriptor 2nd cycle**	**EQF Level 7**	**CM-UGent**
9. Critically reflect on topical rural development issues, and on ethical and value driven aspects of research and intervention strategies	Formulate judgments	Societal competence: awareness of the relation between research-society and integrate ethics and values in actions	CM 5
10. Work in an integrated internationally composed team dealing with rural development and food production challenges, interacting respectfully with diverse others and developing a global perspective	Apply knowledge and understanding	Collaborate and communications: collaboration in multidisciplinary environment	CM 4
11. Dialogue and professionally interact with different actors and stakeholders of the socio-professional world (food sector, NGOs, rural organisations, rural administration, universities and research institutes)	Communication skills	Collaborate and communications: professional communication skills	CM 4
12. Communicate convincingly (written, oral, using appropriate tools) about (own) research findings and project results and their underpinning rationale	Communication skills	Collaborate and communications: professional communication skills	CM 4
13. Effectively and appropriately use good language, communication and behavioural skills in different language and cultural environments	Communication skills	Collaborate and communications: professional communication skills – other language and culture	CM 4
14. Design and plan own learning processes based on continuous reflection (individually and in discussion with others) upon personal knowledge, skills, attitudes and functioning	Learning skills	Intellectual competence: attitude of lifelong learning, show continuous willingness to develop new ideas and processes	CM 3
15. Self-Directed Learning: work independently; take initiative and manage a project through to completion	Learning skills	Professional competence: independently deal with research and complex problems	CM 3
16. Independently perform scientific research in the domain of rural development. Give proof of a clear international orientation	Formulate judgements	Professional competence	CM 6

Addressing current and future agricultural workforce needs to meet societal challenges – A USDA vision

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Abstract. The world's food systems and our ability to ensure global food security are being impacted by major challenges and risks, including climate change, diminishing land and water resources, changing incomes and diets, increasing urbanization, environmental degradation, and the need to ensure better health outcomes. We believe the solution to these pressing challenges lies in transformative discoveries, translation of discoveries into innovations and solutions delivered to the end users, and education of the pipeline of young people needed. From the educational perspective, there is need to incentivize young people to enter agricultural fields and to provide the rigorous education such that they have sustainable livelihoods. A recent study by Purdue University concluded that the United States will produce an average of 67,900 jobs per year between 2015 and 2020 for graduates with a bachelor's degree or higher in agriculture-related fields; however, there will only be an average of 35,400 new graduates in these fields. The Agricultural Science Workforce survey undertaken by the Coalition for a Sustainable Workforce concluded that the top-paying jobs would require graduate degrees, including PhDs. Recent analyses undertaken by the Science, Technology, Engineering, and Mathematics (STEM) Food and Ag Council indicates that during the next five years, the United States agricultural workforce is expected to grow by 4.9 percent, adding 33,100 new positions. All three studies indicate that there are significant shortages in several areas, including plant and animal breeding, crop and animal sciences, entomology and plant pathology, weed science, soil science, food science and engineering, natural resources engineering, and agribusiness. Additionally, with the aging farm population – the current average age of the American farmer is 58.3 years – there's a critical need to attract young people to produce food. This paper offers a few approaches that the U.S. Department of Agriculture (USDA) believes will ensure that a well-trained workforce is available and ready to undertake challenges associated with meeting the nutritional needs of a growing global population.

Keywords. Agriculture – Education – Food Production – Workforce Development – USDA.

Prise en compte des besoins actuels et futurs en capital humain dans l'agriculture pour répondre aux défis sociétaux – La vision de l'USDA

Résumé. *Les systèmes alimentaires mondiaux et notre capacité pour assurer la sécurité alimentaire globale sont confrontés à des défis et des risques majeurs, notamment le changement climatique, la diminution des terres et des ressources en eau, la modification des revenus et des diètes, l'urbanisation croissante, la dégradation environnementale, et le besoins d'assurer de meilleurs résultats de santé. Nous pensons que la solution à ces défis pressants repose sur les découvertes transformatrices, la traduction des découvertes en innovations et solutions offertes aux usagers finaux, et l'éducation dès maintenant des jeunes qui seront nécessaires pour ce faire. Sous l'angle de l'enseignement, il est nécessaire d'encourager les jeunes à entrer dans le domaine de l'agriculture et de leur fournir une éducation rigoureuse leur permettant de gagner leur vie de façon soutenable. Une récente étude de l'Université de Purdue conclut que les États-Unis produiront une moyenne de 67 900 postes de travail par an entre 2015 et 2020 pour des diplômés ayant un BSc ou plus dans les domaines liés à l'agriculture ; toutefois, il n'y aura en moyenne que 35 400 nouveaux diplômés dans ces filières. Une étude (Agricultural Science Workforce Survey) entreprise par la Coalition for a Sustainable Workforce a conclu que les postes de travail les mieux payés concerneraient des diplômes universitaires, y compris des PhD. Des analyses récentes menées par Science, Technology, Engineering, and Mathematics (STEM) Food and Ag Council indiquent que sur les cinq prochaines années, le marché du travail agricole des*

États-Unis augmentera prévisiblement de 4,9%, avec 33 100 nouveaux postes. Ces trois études montrent qu'il existe une pénurie significative dans plusieurs domaines, y compris en amélioration végétale et animale, sciences culturales et animales, entomologie et pathologie végétale, science des mauvaises herbes, science du sol, science et ingénierie des aliments, ingénierie des ressources naturelles, et agroindustrie. De plus, avec une population agricole vieillissante – actuellement l'âge moyen d'un agriculteur américain est de 58,3 ans – il est crucial d'attirer les jeunes vers la production d'aliments. Cet article offre quelques approches qui, selon le U.S. Department of Agriculture (USDA), permettront de disposer d'une force de travail bien formée et prête à affronter le défi de nourrir une population mondiale croissante.

Mots-clés. *Agriculture – Education – Production alimentaire – Développement d'une force de travail – USDA.*

I – Introduction

There is significant rethinking in the United States in regards to higher education in agriculture and transformative changes are called for to better prepare graduates for the future (NRC, 2009a). Kunkel *et al*. (1996) concluded that "the purpose of education in agriculture is to provide for the needs of society and industry in a changing world, to produce graduates with flexibility, diversity, perspective and values". Similarly, in *Agriculture and the Undergraduate* (NRC, 1992), the National Research Council asked how do we educate students to meet the demands of the world, such as global competitiveness and hunger, inequities in food distribution, as well as environmental and health issues (NRC, 1992). Building on this vision are recent and urgent calls for action, including the *Report to the President on Agricultural Preparedness and the Agriculture Research Enterprise* (PCAST, 2012a); *Achieving the New Vison for Agriculture: New Models for Action* (WEF, 2013); *Building a Common Vision for Sustainable Food and Agriculture* (FAO, 2014); and a report from The Chicago Council on Global Affairs (Bereuter and Glickman, 2015) that challenges the US to leverage the strength of its research infrastructure to introduce a major transdisciplinary initiative to train the next generation of agriculture, food, and nutrition leaders through research partnerships, work force development, and outreach services in developing countries.

According to the United Nations (UN, 2013), the world population is predicted to reach 9.6 billion by 2050, just 35 years from today. If this prediction is accurate, humankind's greatest challenge may be feeding this population. To feed a population of 9.6 billion, the Food and Agricultural Organization (FAO) projects that agricultural production (food, feed and fiber) will need to increase by 70 percent (FAO, 2009). In order to achieve this global food security, we will need to improve agriculture and its distribution, reduce waste, ensure safe food for us and our ecosystems, as well as use our crops effectively and nutritiously, while providing livelihoods to farmers and rural communities (Economist, 2011). Furthermore, it is estimated that about one-third of the world population (about 1 billion people) go hungry every day, crops are used for bioenergy and other industrial purposes, and the future demand for food will increase the pressure on scarce environmental resources.

As we look toward the future, our "education vision" needs to include "what is good agriculture?" The World Economic Forum concludes that the world needs a new vision of agriculture (WEF, 2013). We believe the solution to these pressing challenges lies in education, inspiring our young people to enter agricultural fields and providing the rigorous education these disciplines demand.

II – Scope

The National Institute of Food and Agriculture (NIFA) is one of the USDA's agencies that was created by the 2008 Farm Bill to catalyze transformative discoveries, education, and engagement to address agricultural challenges. NIFA is advancing science by focusing on six significant societal challenges: food security, climate variability and change, water, sustainable bioenergy, childhood obesity prevention, and food safety (NIFA, 2014). To meet these challenges, a new generation of well-prepared, innovative scientists in the agricultural sciences and natural resources is necessary.

However, US education is not producing enough agricultural scientists to meet the growing demand. The number of students enrolled in production agriculture has been declining as well as the proportion of graduate students concentrating in agricultural sciences. Academic leaders in agricultural education are very concerned and industry leaders are spending increasing amounts of money to train new employees who have majored in other scientific disciplines to work in agricultural areas (AAAE, 2012). In general, US students are not interested in pursuing careers in science, technology, engineering, and mathematics (STEM), which have major implications for sustaining American competiveness and economies in agriculture and other industries (NSB, 2007).

Exacerbating the problem, the capacity of existing US students has been declining. American students are no longer ranked in the top 20 countries in math and science capability. Less than half of the ACT test takers are prepared to take college level math and science (ACT, 2014). Congress and federal agencies have been responding to the need to produce more STEM students. However, this may not translate into more students going into agricultural sciences and related sciences without additional incentive programs.

Education is one of the current Administration's priorities. In particular, President Obama emphasizes the need to "increase STEM literacy so that all students can learn deeply and think critically in science, math, engineering, and technology." He calls on the country to "address college completion and strengthen the higher education pipeline to ensure that more students succeed and complete their degree". The President also wants to "invest in community colleges to equip a greater share of young people and adults with high-demand skills and education for emerging industries".

Innovative colleges and universities have begun to develop programs to recruit students into agricultural sciences (OSTP, 2012). Programs like these must be expanded in order to meet the country's challenges in the agricultural and natural resource sciences and meet the societal challenges being addressed by NIFA. USDA is committed to meet a significant and growing need in agriculture – producing more agricultural scientists by helping to build a pipeline of talent that sustains America as the world's leader in agricultural innovation.

III – Guiding principles

America's food and fiber producers operate in a global, technologically advanced, rapidly diversifying, and highly competitive business environment (Pardey *et al*., 2013). Therefore, USDA is constantly helping agricultural producers and industry meet the needs of the nation and of the world. In addition, with the continuous changes of agricultural policies and farming methods, it is crucial that agricultural education evolves with them, pushing towards innovations rather than accepting conventions (ASPB, 2013; NRC, 2009b).

A supportive infrastructure including academic institutions, purposeful and mission-oriented curricula, engaged students at all levels, sound education policies, and budgetary commitments will be the key ingredients in defining any renewed vision to redefine agricultural education that is supportive of our grand agricultural challenges. While multiple USDA agencies are engaged at various levels in providing both formal and non-formal teaching, learning and training opportunities, NIFA serves as the lead USDA agency with legislative authorities that support agricultural education in a broader sense. These programs include funding to support education infrastructure at land-grant universities as well as ensuring that our education system is being responsive to the changing demographics across the country. In addition to 58 land-grant universities established through the Morrill Act of 1862, of notable mention are NIFA's programs that support educational activities in 19 historically black land-grants established via Morrill Act of 1890, as well as 34 American Indians colleges and universities authorized by Congress as land-grants in 1994. Education opportunities are also afforded to Hispanic populations through education programs targeted for numerous Hispanic serving institutions.

USDA's priority setting process for research, education, and extension activities includes feedback from its stakeholders. In 2013, USDA organized an education listening session that engaged a cross section of educators, policy makers, and community organizations. As a result, USDA received several excellent suggestions that can easily be considered as the guiding principles for USDA's education strategy.

Salient recommendations from the education listening session were**:** (1) teacher training is critical, (2) agriculture needs to transform its image – from the cow and cook club – to food, technology, conservation, and cutting-edge science, (3) students need to know that agriculture offers fun, interesting, satisfying, and secure jobs for graduates with 2-year technical degrees, BS and MS degrees, as well as those with PhDs, (4) blended learning (a mix of hand-on experience and formal education) is the best approach, (5) job shadowing, mentoring, internships, and scholarships are essential keys to students retention, (6) research grants must include teaching and outreach components. Even better, a new challenge area funding agricultural education should be added to the NIFA portfolio, (7) USDA needs to be more effective in listening and communicating with its stakeholders, (8) USDA needs to lead a national initiative on agricultural education that includes new curricula, audiences, and image for agriculture. USDA needs to make sure it's leading the industry and not letting others define the future of agriculture, food, and natural resource education, and (9) 4-H and Extension are good models for informal education and transferring knowledge and these models need to be effectively connected to the nation's food, cutting-edge science and technology, and conservation.

IV – What is the current reality?

College graduates in the United States are severely lacking basic skills (job skills) – especially problem solving, decision making and the ability to prioritize tasks (Silingo, 2015). Similarly, the Collegiate Learning Assessment Plus (CLA, 2015) found that 40 percent of college seniors lack the reasoning skills needed in today's workplace. In addition, the skills of graduates depended on their college major. Math and science students scored significantly higher than those in other disciplines. Furthermore, the Association of American Colleges and Universities Survey (APLU, 2015) found that employers consistently rated students much lower than students judged themselves. For example, 26 percent of employers said graduates had critical thinking skills compared to 66 percent of the graduates (students). These findings confirm what companies have long complained about – that many college graduates are not ready for work and the global job market.

In 2015, an employment outlook report released by NIFA and Purdue University (Goecker *et al*., 2015) concluded that there is an average of 35,400 new United States graduates with a bachelor's or higher degree in agriculture-related fields, 22,500 short of the jobs available annually. Basically, there are not enough agricultural scientists to meet the demand. According to the report's projections, between 2015 and 2020, our nation expects to see 57,900 average annual openings for graduates with a bachelor's degree or higher in agriculture-related fields. The Agricultural Science Workforce survey concludes that the top-paying jobs would require graduate degrees, including PhDs (CSAW, 2013). Recent analyses undertaken by the STEM Food and Ag Council indicate that during the next five years, the US agricultural workforce is expected to grow by 4.9 percent, adding 33,100 new positions (SFAC, 2014). Taken together, these results indicate that most of the demand is in specialized areas, such as plant breeding/genetics, plant protection, plant sciences, and animal sciences (Buchanan, 2014). One must not forget that the average age of the American farmer is 58.5 years and there were 4.3 percent less farms in 2012 than in 2007 (NASS, 2012).

These reports show that there is an incredible opportunity for highly-skilled jobs in agriculture, which will address some of the world's most pressing challenges, such as developing solutions to feed 9 billion people by 2050.

V – What are we doing?

The USDA's vision for education starts with helping students cross the K-20 continuum (kindergarten through college). We see these challenges and opportunities partitioned into three components, (1) learning and engagement, (2) workforce development – the next generation of farmers and scientists, and (3) capacity building. Improving these components will help USDA strengthen the science literacy and other 21st century skills into a pipeline between secondary and higher education so that our students will be better positioned for the global marketplace.

1. Coordinating Education across USDA Agencies

USDA's Office of the Chief Scientist through its Science Council chartered an Education Coordinating Committee to improve coordination of all USDA education activities and to leverage resources to build effective partnerships across the US federal enterprise. All seven USDA mission areas and the 12 agencies are represented in this education coordination effort. This committee developed the USDA's education portfolio around five common themes: (1) learning and engagement, (2) training and education, (3) internships, (4) capacity building, and (5) educational campaigns and outreach. In addition, the committee ensures synergy and best practices among these diverse agencies and their programs.

Each USDA agency contributes to the education portfolio and its activities. For example, the Agricultural Research Service (ARS), USDA's principal intramural scientific research agency, is involved in training the next generation of scientists through graduate assistantships, traineeships and mentoring. The National Agricultural Statistics Service (NASS) supports graduate fellowships, internships and provides statistics for K-12 education. The Economic Research Service (ERS) provides education-related research and data – socioeconomic data and research on education and the relationship between education, economic activity, as well as household well-being with a particular emphasis on the rural economy. In addition, ERS supports distance learning through a program that puts agency scientists into the classrooms of minority-serving institutions using interactive real-time video seminars.

The Food Safety and Inspection Service (FSIS) provide consumer education, which is coordinated at its Office of Public Affairs and Consumer Education. The Food and Nutrition Service (FNS) primary job is to educate consumers about food. FNS has a series of Web and printed content targeted at different age groups, including "Healthier Middle Schools," and "Nutrition Voyage." Another example is "Serving Up MyPlate," a new collection of classroom materials that helps elementary school teachers (grades 1-6) integrate nutrition education into math, science, English, language, arts, and health (FNS, 2012). This curriculum introduces the importance of eating from all five food groups using a variety of hands-on activities. Students also learn the importance of physical activity to staying healthy.

The Animal and Plant Health Inspection Service (APHIS) develops and applies scientific methods that educate consumers, protect the health of American animal and plant resources, and sustain agricultural ecosystems. Rural Development (RD) has no formal education programs, but instead focuses on providing information to rural communities. One way this is done is through teaching the cooperative business model to secondary education level students using instructor guides and lessons. Finally, the Forest Service (FS) is engaged in educating the nation about forests, natural resources, and other conservation issues. FS conservation education includes outreach products that focus on educating children and families about conservation issues. For example, the “Natural Inquirer” is a middle-school science journal about America’s forests and research that promotes active learning through the scientific process. Each year, the FS distributes more than 60,000 journals to classrooms across America.

NIFA is involved in educating and training the next generation of agricultural employees. These include: (1) the beginning farmer and rancher initiative to address the dearth in farming skills among new farmers, (2) education and literacy initiative to help develop the K-20 pipeline in the setting of formal education, and (3) 4-H and youth development programs to help engage youth in the entire food, agriculture, natural resources and human science spectrum.

2. NIFA’s Beginning Farmer and Rancher Development Program

NIFA’s Beginning Farmer and Rancher Development Program (BFRDP) was launched in 2009 to support local and regional training, education and outreach, and technical assistance to address the critical needs of beginning farmers. Training is offered in a variety of topics, including (1) production and management strategies to enhance land stewardship by beginning farmers and ranchers, (2) business management and decision support strategies that enhance the financial viability of beginning farmers and ranchers, (3) marketing strategies that enhance the competitiveness of beginning farmers and ranchers, and (4) legal strategies that assist beginning farmers with farm or land acquisition and transfer. BFRDP complements several programs offered by other USDA agencies to support beginning farmers. These programs provide for voluntary participation, offer incentives, and focus on equity in beginning farmer opportunities for all communities.

3. NIFA’s Education and Literacy Initiative

In 2012, the President’s Council of Advisors on Science and Technology (PCAST, 2012a) identified a few challenges and offered recommendations to boost agricultural research enterprise in the United States. PCAST concluded that the US Agriculture workforce challenges include (1) support for a well-trained workforce (primary concern); (2) the best students do not view agriculture as an attractive career option; (3) the industry has difficultly recruiting the technical employees for its research programs; (4) the talent pipeline begins well before college admission; (5) at the baccalaureate level, a comprehensive array of undergraduate programs relevant to agriculture and the food industry are needed and; (6) USDA, in collaboration with NSF, expand its national competitive fellowship program for graduate students and post-doctoral researchers.

In support of USDA’s Goal of Education and Science Literacy as well as in responding to the PCAST’s recommendations, NIFA recently launched a new Education and Literacy Initiative (ELI) offered through a competitive funding mechanism. USDA’s guiding principal is that education must be more than learning facts. Students also must be offered the opportunity to be incorporated into and be involved in the discovery through delivery continuum, i.e., experiential learning in both the research (discovery) and extension (delivery and engagement) domains. The goal of ELI, therefore, is to produce graduates with skills needed to address the new challenges of the 21st century in food, agricultural, natural resources, and human sciences.

This program has now evolved with a focus on immersive learning experiences in non-formal education to help secondary school teachers identify and integrate successful lessons in their classes; enhance capacity of academic institutions to produce graduates with work-ready skills with special emphasis on research and extension based experiential learning opportunities for undergraduates; and advance science by supporting graduate and postdoctoral education. The overarching theme that clearly echoes throughout USDA/NIFA education programs is that a robust workforce is essential if the United States is to face predictable and unpredictable challenges and opportunities in the food and agricultural sectors.

4. 4-H and Positive Youth Development

Headquartered at USDA, 4-H is the nation's largest youth development organization, empowering millions of young people throughout the United States. 4-H reaches every corner of our nation – from urban neighborhoods to suburban schoolyards to rural farming communities. 4-H started as an agricultural-based youth organization and has today evolved into an education program that focuses on citizenship, healthy living, as well as science and technology programs.

Through the land-grant universities and their Extension System, and partnering with the USDA and NIFA, as well as county governments and communities, 4-H helps shape youth in the United States like no other youth organization. The 4-H vision is to prepare young people to make a positive impact in their communities and the world. For example, a study conducted by the Tufts University (Lerner and Lerner, 2011) reported that participants in 4-H, compared to young people involved in other non-formal programs (i.e., Boys & Girls Clubs, Big Brothers/Big Sisters, YMCA, and scouting), had (1) better grades, (2) more wanted to pursue careers in STEM disciplines, and (3) planned and applied to college. Tufts research indicates that involvement in 4-H programs substantially increases life skills and youth development in a non-formal learning environment.

VI – What is the way forward?

The evidence indicates an acute shortage and immediate need for significantly more agricultural graduates than currently being produced in the U.S. There may not be an easy or a single solution to accomplishing this challenge. However, it must be addressed to ensure that our future workforce and next generation of scientists is indeed fully trained and equipped with the skill set needed to make innovations and discoveries in meeting future food demands and solving societal challenges dependent upon the agricultural enterprise (PCAST, 2012b).

Agriculture is much more than simply growing plants or raising animals. It has increasingly become a science and technology based complex, interdependent, and multifactorial enterprise. There is a clear convergence of biophysical and social sciences that seems to be working hand in hand in taking science and discoveries from the lab to the street. Governance of agricultural enterprise has to keep up with constantly changing social and regulatory oversight. Our workforce needs to be trained in "systems approach" as opposed to a silo-based training in a single subject matter expertise. Therefore, entities such as academia, industry, policy makers, funding agencies, and societal leaders – all have a distinct role to play towards a cohesive agriculture production system. Academia needs to be able to offer state of the art education and training that is clearly aligned with and supportive of the needs of production agriculture. Youth must be engaged much earlier through formal and non-formal education in activities that spark their interest in their joining and supporting both biophysical and social sciences aspects of production agriculture.

Community and technical colleges will be key players in that they work closely with local government, industry partners, workforce intermediaries, as well as community members to identify existing and emerging sectors workforce needs and prepare students accordingly. With 2014 enrollment levels of 12.8 million, the nation's 1,167 community colleges enroll 45 percent of all undergraduate students in the United States, 51 percent of minoritiy undergraduate students, as well as 36% of first generation college students, and are key to ensuring that the nation has the workforce it needs (AACC, 2014). We must ensure that community colleges are an integral part of the agricultural workforce pipeline. Several US universities have developed 2 + 2 articulation programs with the community colleges so that a student interested in higher education can jump to a four-year college as a part of the agriculture education pipe line continuum.

Indeed, all such considerations need funding. USDA is committed to championing the worldwide funding of agricultural education, extension and research programs to increase productivity, minimize international trade distortions, improve rural education and job creation in developing countries, reduce food waste and find ways to meet the food needs of the world's chronically undernourished and malnourished population (Hofstrand, 2011). A recent review of USDA/NIFA competitive programs by the National Research Council (NRC, 2015) recommends that funding for NIFA's competitively awarded programs should be increased significantly. Such a support will further strengthen a diverse education portfolio within USDA and help establish partnerships with other federal agencies with common interests in supporting this education enterprise. USDA is playing a leading role in support of President Barak Obama's charge that "We must educate our children to compete in an age when knowledge is capital, and the marketplace is global."

USDA believes that innovation is a key ingredient – and that we educate to innovate. A USDA-funded research program developed submergence-tolerant rice bred to survive underwater (Xu, *et al*., 2006). This new rice yields are more than double the old varieties. It is predicted that 20 million farmers in India, and other flood-affected areas, will plant these new varieties. In this regard, the US agriculture has greatly benefited over the years from Cooperative Extension Service that has taken the innovative scientific discoveries to the streets for the benefit of the society at large. Indeed, USDA's investment in partnership with national and global entities has led the way in sequencing genomes of crop plants, domestic animals and microorganisms. These genome sequences are of great value for agriculture productivity, bio-based materials manufacturing, industrial bioprocessing, and biodiversity conservation as well as for disease diagnosis, treatment and prevention (Hoffman and Furcht, 2014). USDA is committed in ensuring that the next generation of scientists is available and ready to take advantage of cutting-edge discoveries to be unearthed during this genomic exchange era. Finally, discipline-based gaps in agricultural sciences expertise – for example, plant breeding, animal breeding, integrative plant and animal sciences, food process engineering, and pest management – need to be met through targeted training grants.

VII – Conclusions

Today, the world is facing major challenges. According to the United Nations (UN, 2013), the world population is predicted to reach 9.6 billion by 2050, just 35 years from today. If this prediction is accurate, humankind's greatest challenge may be feeding this population. To feed a population of 9.6 billion, FAO projects that agricultural production (food, feed and fiber) will need to increase by 70 percent (FAO, 2009). The world's food system is inundated by major challenges and risks, such as food security, agricultural sustainability, and economic opportunity.

The World Economic Forum concludes that the world needs a new vision of agriculture (WEF, 2013). Vision is basically rethinking what is possible. Therefore, the USDA is rethinking its agricultural education mission to present a framework for making transformative changes in higher education in agriculture. As we look toward the future – we have reached the point in history where we must answer two questions – "What's for Dinner?" and "Will there be food for tomorrow?" These basic questions clearly show the importance of agriculture. Finally, echoing Freudenberger's (1994) question, "Is there any subject more critical?"

We believe the solution to these pressing challenges lies in education, inspiring our young people to enter agricultural fields and providing the rigorous education these disciplines demand.

USDA's agricultural education pipeline takes an overarching approach through the involvement in 4-H programs that substantially increases life skills and youth development in a non-formal learning environment; provides immersive learning experiences in non-formal educational programs for secondary school educators, enabling them to identify and replicate best practices to enhance student outcomes in the food, agricultural, natural resources, and human sciences; engages undergraduates through experiential learning opportunities so that they are better prepared to join the workforce; and lastly, train the next generation of scientists through pre-and-post doctorate fellowship experiences.

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An international cooperation model: CIHEAM-IAMZ training activities

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Abstract. Since its foundation in 1969, advanced training has been the essence of the activities conducted by the Mediterranean Agronomic Institute of Zaragoza (IAMZ). IAMZ fulfils its mission, as an axis of international cooperation within the scope of agriculture, food and the environment, through two complementary training programmes: degree-leading and short duration advanced postgraduate courses for professionals. They are both clear, effective instruments of international cooperation, based to a large extent on synergies established with Spanish and international institutions of excellence. We review the activities carried out at IAMZ over the last 25 years and make a critical analysis of the demand and the pros and cons of these training programmes.

Keywords. Postgraduate training – Master Programmes – Lifelong-Learning.

Un modèle de coopération internationale : les activités de formation du CIHEAM-IAMZ

Résumé. *Depuis la fondation de cet établissement en 1969, la formation supérieure est au cœur des activités menées par l'Institut Agronomique Méditerranéen de Zaragoza (IAMZ). L'IAMZ accomplit sa mission, en tant qu'axe de la coopération internationale dans le domaine de l'agriculture, l'alimentation et l'environnement, à travers deux programmes de formation complémentaires : la formation diplômante et les cours postgraduates approfondis de brève durée pour professionnels. Ces deux modalités constituent des instruments avérés et efficaces de coopération internationale, fondés sur une vaste base de synergies bâties avec des institutions d'excellence espagnoles et internationales. Nous passons en revue les activités menées par l'IAMZ sur les 25 dernières années et faisons une analyse critique de la demande, et des avantages et inconvénients de ces programmes de formation.*

Mots-clés. *Formation postgraduate – Programmes de Master – Apprentissage tout au long de la vie.*

I – Introduction

CIHEAM is an intergovernmental organisation founded in 1962 upon the initiative of the Council of Europe and the Organisation for Economic Cooperation and Development (OECD), due to a great extent to the imagination, persistence and perseverance of Ramón Esteruelas, the Spanish Delegate at the OECD and first CIHEAM president from 1962 to 1983. The creation agreement was signed on 21 May 1962 by France, Italy, Greece, Portugal, Spain, Turkey and former Yugoslavia. CIHEAM's mission is to develop cooperation between Mediterranean countries through postgraduate training and promotion of cooperative research in the field of agriculture and natural resources. The Organisation currently has 13 member countries: Albania, Algeria, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Portugal, Spain, Tunisia and Turkey. The General Secretariat is in Paris (France) and activities are organised mainly in the four Mediterranean Agronomic Institutes in

Montpellier (France) (IAMM, created in 1962), Bari (Italy) (IAMB, 1962), Zaragoza (IAMZ, 1969) and Chania (Greece) (MAICh, 1983).

When designing the training programmes, CIHEAM aims to encourage international cooperation by offering complementary and specialised training from the four institutes. CIHEAM delivers, through the four Institutes, 20 Master programmes in an international and multicultural framework and offers a wide range of short duration specialised advanced training activities in fields such as "Food Production and Quality Management", "Environment and Natural Resource Management", "Economics, Management and Development Policies" and "Fisheries and Aquaculture". The CIHEAM Governing Board, in accordance with its academic regulations and objectives, formally approves the yearly course catalogue. Besides this direct involvement in training, CIHEAM has signed agreements with a large number of higher education and research institutions from various countries, particularly in the Mediterranean. Agreements are also extended to the main international institutions active in the Mediterranean region within the scope of agriculture, food, environment and natural resources. Joint postgraduate training activities are organised with some of these institutions and studies and credits are mutually recognised.

The Mediterranean Agronomic Institute of Zaragoza is particularly active in postgraduate training. It is structured in five study areas: Animal Production (AP), Environmental Sciences (ES), Fisheries and Aquaculture (FA), Food Science, Technology & Marketing (FSTM) and Plant Production (PP). It is located on the research campus of Aula Dei, one of the oldest and most prestigious in Spain, also founded upon the initiative of CIHEAM's first president. IAMZ interacts closely with the other three institutions on campus: the Experimental Station of Aula Dei and the Pyrenean Institute of Ecology, both belonging to the Spanish National Research Centre (CSIC), and the Centre for Agro-food Research and Technology (CITA) of the Government of Aragon.

II – Training Programmes

Since its foundation in 1969, postgraduate training has represented the essence of IAMZ's activities (Fig. 1). In the last 25 years, IAMZ has received more than 36,000 applications to follow postgraduate courses from more than 150 countries. Approximately one out of every three has been selected, that is, more than 12,000 professionals from 135 countries, being 83% from CIHEAM member countries. Likewise, almost 12,000 guest lecturers have participated in IAMZ postgraduate training.

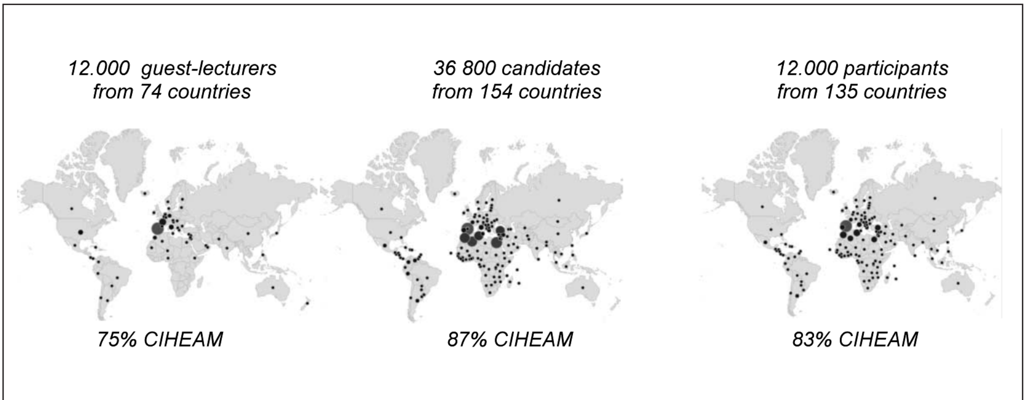


Fig. 1. Geographical origin of candidates, participants and guest lecturers in training programmes organised by IAMZ-CIHEAM in the last 25 years.

CIHEAM delivers two complementary postgraduate training programmes. The Master of Science programme has been running since the end of the 1970s. The life-long learning programme for professionals is based on advanced specialisation courses that last between one and two weeks. On average, IAMZ organises 12 of these courses per year, approximately 25% of which are delivered outside our Zaragoza premises.

The original training offered by the CIHEAM institutes has varied over the years. The progression of IAMZ has followed three general principles: (1) the natural evolution of its original vocation of agricultural production and the environment, incorporating fisheries and aquaculture; (2) agro-food marketing and food processing as a means to generate added value to the primary production and; (3) synergies sought with Spanish and international institutions in relevant topics for the Mediterranean.

The IAMZ does not have permanent teaching staff and bases its education activities on guest lecturers. Over 350 speakers are invited to IAMZ's courses every year; university lecturers (40%) researchers from public research centres (38%), senior business managers (10%), professionals from the public administrations (6%) and experts from international bodies (6%). The fact that lecturers come from a wide range of geographical regions and institutional bodies, gives an added impulse to the courses where participants meet different theories, methodologies and results.

1. The CIHEAM Master of Science

The CIHEAM Master of Science programme arises from a study entrusted to an international commission of experts in the mid 1970s by the Governing Board in order to revise the criteria followed in the awarding of CIHEAM diplomas and in particular to define the conditions for the creation of a new postgraduate diploma such as "*Magister Scientiae*". The objective was based on postgraduate education, endorsed by the Master of Science degree, at that time without official academic recognition in the majority of the Mediterranean countries, but with a long-standing tradition in the English-speaking education systems.

In 1977, the Governing Board decided that the diploma awarded by the Centre be called "CIHEAM Diploma of Advanced Studies" (*Diplôme de Hautes Études du CIHEAM*), with a level of Master of Science. In order to access the Master programmes, candidates may be of any nationality but should have a four-year university qualification from their country of origin that allows them access to official postgraduate studies. CIHEAM's objective is to provide postgraduate specialisation through initiation to research and to professional life, transmission of knowledge, development of critical understanding and capacity of analysis and assessment as well as the improvement of applied skills. In the same year, the conditions of the diploma were defined to correspond to a two-year higher postgraduate training programme consisting of a specialisation course in the first year and the preparation and defence of a thesis before an examining board in the second. At IAMZ the first CIHEAM Diploma of Advanced Studies of the Master programme was awarded in May 1981 in Animal Production. Since the academic year 1987-1988 the Master programmes have been developed biennially.

Since the Bologna Process for the convergence of European graduate and postgraduate studies, CIHEAM has adjusted its educational activities to the European Higher Education Area) by applying an analogous qualification and credit system to the European Credit Transfer System (ECTS). The CIHEAM Master of Science Degree currently awards 120 credits over two academic years, namely 30 weeks of full-time lectures each academic year and has introduced a diploma supplement also analogous to the European university system. IAMZ actively participates as a higher education centre of the Erasmus+ programme, for both incoming and outgoing students. Practically all the Master programmes have already been approved in the *ex ante* verification and *ex post* accreditation processes by the assessment body of the State or the Autonomous Community for the quality of university studies.

The IAMZ – CIHEAM strategy in the current educational context, marked to a large extent by the Bologna process, has focused on three complementary principles:

1. To achieve official recognition of the Master of Science Degree awarded by CIHEAM through IAMZ as equivalent to the official Spanish Master Degree. This official recognition was achieved in 2006, IAMZ being the first institution to appear in the University Degree National Registration Office of the Spanish Ministry of Education in the section “Other Centres of Higher Education”.
2. To seek more intense collaboration with various Spanish universities, establishing alliances to co-organise Master programmes in accordance with the principle of double qualifications. A number of IAMZ’s Master programmes are co-organised with the following institutions: the Autonomous University of Barcelona, the Universities of Alicante, Córdoba, Las Palmas de Gran Canaria, Lleida, Zaragoza and the Technical University of Valencia. However, these alliances have had to overcome certain difficulties due to strategic and structural differences between institutions.
3. To strengthen differentiating features, especially the international dimension of lecturers and participants and introduction to research as the main axes of the training activities. The excellence of some of our programmes has been recognised by external assessment agencies, as well as the high degree of internationalisation and superior educational value.

In Zaragoza, lecturers are delivered in English, French, or Spanish. Simultaneous translation is provided from English and French into Spanish. As participants should have knowledge of Spanish, an intensive language course is organised from July to October for those that require it. Knowledge of English and French is also valued as part of the documents distributed by lecturers could be in either. Exams may be taken in Spanish, French, or English.

In the last 25 years, approximately 2400 students from over 60 countries have followed Master studies at IAMZ, 77% of whom come from CIHEAM member countries (45% from non-EU countries, practically all with a scholarship, 47% from Spain and the remaining 8% from other CIHEAM countries belonging to the UE); 19% from Latin America and about 1-2% from non-CIHEAM Mediterranean countries, from other parts of the EU and the rest of the world (Fig 2). IAMZ awards a full scholarship covering tuition fees, travel, board and lodging to most selected students from non-EU CIHEAM member countries.

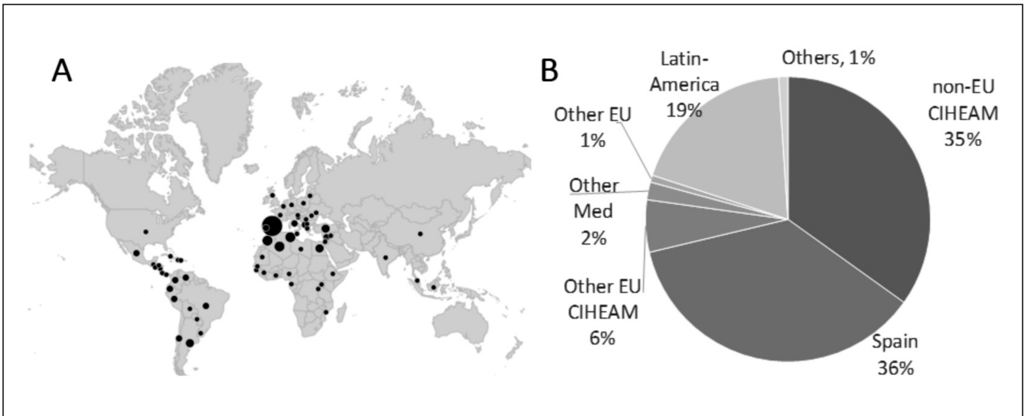


Fig. 2. Geographical Origin of the 2396 students from 64 countries registered in IAMZ-CIHEAM Master programmes in the last 25 years.

IAMZ currently offers nine official Master Degrees that are delivered every two years, seven of which are jointly organised with eight Spanish universities. Four of these Masters are delivered at IAMZ. IAMZ also participates in an Erasmus Mundus Master programme, with a further six non-Spanish higher education institutions.

Agro-food marketing

Animal nutrition — Universidad Zaragoza

Integrated planning for rural development and environmental management — Universitat de Lleida

Plant breeding — Universitat de Lleida

Animal breeding and reproduction biotechnology — Universidad Politecnica de Valencia; UAB Universitat Autònoma de Barcelona

Aquaculture — Universidad de Las Palmas de Gran Canaria

Olive growing and oil technology — Universidad de Córdoba

Sustainable fishery management — Universitat d'Alacant, Universidad de Alicante

Fig. 3. Master programmes currently offered by IAMZ-CIHEAM alone or co-organised with other Spanish institutions. The first four are offered in Zaragoza and the second four at the co-organizing universities.

The CIHEAM Master programme is organised in two differentiated parts as far as structure and specific learning outcomes are concerned. During the first year (October-June), participants follow a postgraduate specialisation course (awarding 60 ECTS credits). The syllabus includes lectures, seminars, debates, practicals, technical visits, tutored work which aim to encourage dialogue and exchange of ideas between participants, lecturers and professionals of the sector. Training is given by highly qualified experts that are invited to participate for their renowned expertise in each of the topics. Concerning the internationalisation of the lecturers, as examples, over 50 lecturers take part in the Master in Plant Breeding, co-organised by CIHEAM and the University of Lleida. These professionals come from nine countries of the European Union, the United States, Israel and Tunisia. They belong to eight Spanish universities, twelve more from the European Union, two North American universities and a Tunisian university. There are also representatives from twelve public research bodies, five international plant-breeding companies and four international bodies. Thirty five lecturers take part in the Agro-food Marketing programme, 20 from six European Union countries; Spain (9), UK (5), France (2), Germany (1) Ireland (1) and Luxembourg (1), 13 from the USA, 1 from Morocco and 1 from Norway. 71% come from universities in 7 countries; 14% from public research bodies; 9% from firms and 6% from international organisations.

The second year of the Master programme takes place at accredited universities and research centres collaborating with IAMZ, generally in Spain but also elsewhere, under the scientific supervision of a renowned doctor. As in the first year, the collaboration established between IAMZ and numerous prestigious institutions in the various specialities for conducting the Master thesis, is a fundamental element of the programmes' success. Participants develop their training in an environment of team research, counting on excellent resources and expert advice. The experience they acquire during this period goes beyond practical knowledge and skills; they are immersed into real professional and research situations. As a result, more than half of the MSc graduates go on to do a PhD degree and two thirds publish part of their MSc Thesis in specialised, mostly international, journals.

The demand for places on our Master programmes has varied in recent years (Fig 4). The left of the figure illustrates the number of applications received in the last 25 years, both from CIHEAM EU-countries and CIHEAM member countries not belonging to the EU. In global terms there has been a general decline over the years in applications from the EU and an increase in applications from non-EU CIHEAM countries. This decline was more noticeable when the Master reached official recognition, with the increase number of Master degrees offered in Spain.

However, when analysing the three programmes that have not undergone substantial changes in structure (Plant Breeding, Rural Planning and Marketing), very interesting patterns emerge (Fig 4B). The number of EU candidates (mainly Spanish) seems to have recovered slightly in recent years, once the Bologna degrees have been fully implemented. At the same time, the demand from non-EU graduates is decreasing slightly, coinciding once again with the implementation of the Master degree in their own countries more recent than in the EU, in such a way that the ratio between candidates from one type of country or another has changed significantly in the last five years (triangles in Figure 4B).

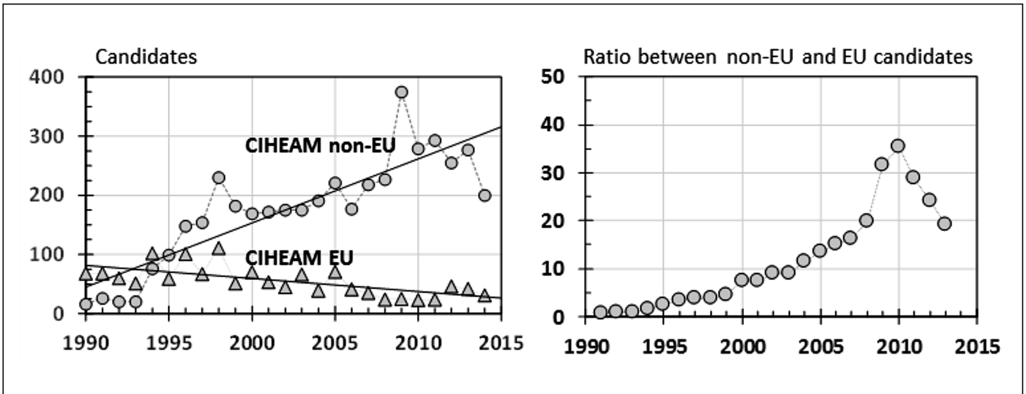


Fig. 4. (A) Number of applicants for IAMZ-CIHEAM Master programmes from non-EU CIHEAM countries (○) and from EU CIHEAM countries (∆). (B) Evolution through time of the ratio between number of applications from non-EU CIHEAM and EU CIHEAM countries (∆).

IAMZ and its partner universities share a longstanding institutional tradition as well as the conviction of the importance of the quality assessment and improvement processes. Such processes do present advantages and drawbacks for a collaborative framework such as IAMZ's in comparison with the university context.

IAMZ has a relatively simple administrative structure and is more flexible to design new programmes and update them, as it is not restricted to a pre-established faculty. As IAMZ does not have permanent teaching staff, highly qualified lecturers can be selected according to their expertise and the continuous assessment system enables IAMZ to react quickly to changes needed for certain training activities. Nevertheless, current quality regulations in the Spanish university system that IAMZ has to follow, despite its international nature, to keep official equivalence of the CIHEAM-IAMZ diplomas in the EU context, limits this IAMZ flexibility, as regulation requires that changes made in the programme to be re-evaluated by the corresponding assessment agency following a tedious and long procedure.

IAMZ dependence on external experts as guest lecturers from other institutions, requires, as compared to the university system, a greater logistical effort and is particularly challenging when coordinating teaching contents and monitoring and tutoring students.

The IAMZ partenariat model extent also to technical/research infrastructure needed to organise some of the laboratory and field practicals in the first part of the programme and to carry out the Master thesis research in the second. Considering the IAMZ philosophy of flexibility, own resources are restricted and synergy is searched with other institutions to be able to offer a greater possibility of applied specialisation to our students.

2. Programme of Advanced Specialised Courses for Professionals

IAMZ is particularly active in organising short (1-2 weeks) duration courses in a large scope of specific advanced agriculture and related sciences. They are aimed at professionals with experience related to the subject matter of the course and provide a high-level update of knowledge, complemented with the possibility of exchanging experiences in an international framework, both with the guest lecturing experts and the professionals attending the course. The offer of courses is updated each year, and they may be repeated several times if there is enough demand. Programmes of this type are not frequent in Spain.

When a new course is proposed, an international group of experts in the subject participate in an *ad hoc* committee, which discusses upon the content and activities of the new programme and design the programme. This group of experts also proposes a panel of guest lecturers. The commission comprises between 5 and 7 university lecturers, researchers from public research bodies, administrators and professionals from private institutions, besides those responsible for IAMZ training and co-organising institutions. One of these members acts as the scientific director that coordinates the scientific aspects of the programme and supervises its delivery.

The total economic cost of a course is substantial, depending on whether it is held on the premises at Zaragoza or elsewhere, mainly because approximately 12 participants from non-EU CIHEAM member countries receive a full scholarship and the number of experts invited to participate in the *ad hoc* commission and to teach. It is worthy of mention that our guest lecturers do not receive high professional fees, their participation being considered as a contribution to international cooperation both on their behalf and that of their institutions.

In the last 25 years IAMZ has organised almost 350 courses, a significant number co-organised with national or international institutions, 23.2% of *ex situ* courses have been carried out, including some that have been organised in non-CIHEAM countries (Fig 5A). Such courses are organised in the five study areas, especially in Fisheries and Aquaculture, which was established as an independent study area 12 years ago (Fig 5B). We organise an average of 14 courses per year with an average of 27 students per course and up to 500 participants per year (Fig 5C).

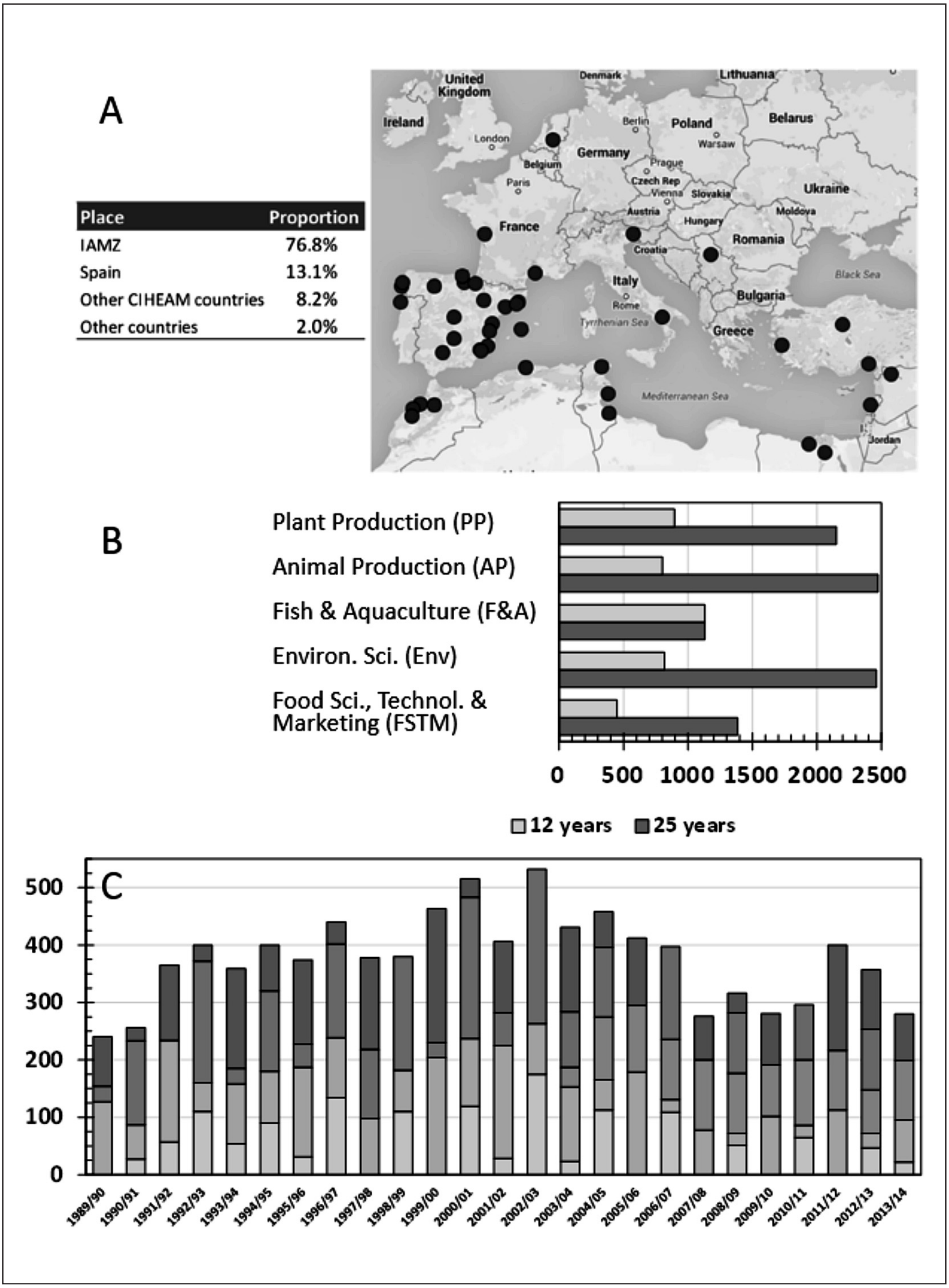


Fig. 5. Short duration advanced courses organised by IAMZ. Locations in which courses organised by IAMZ-CIHEAM have been carried out in the last 25 years (A), Number of participants in courses per study area (B) and years (C).

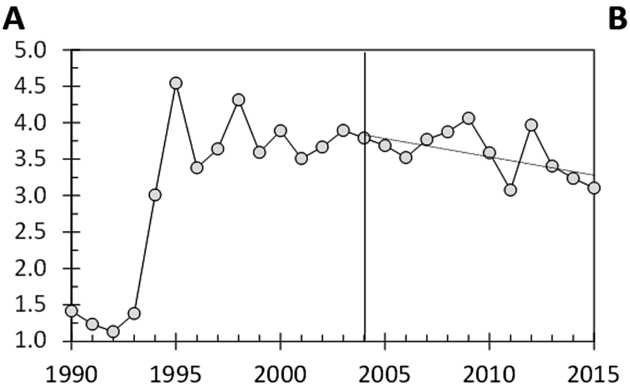
There is a large number of applications and participants, averaging about 1200 and 375 per year; 88% of the candidates come from CIHEAM member countries, the majority (71%) from non-EU CIHEAM countries. Demand from Spanish professionals is also substantial with 21% of total CIHEAM applications (Table 1). Overall success rate of these applications is 32%, varying very much according to country of origin.

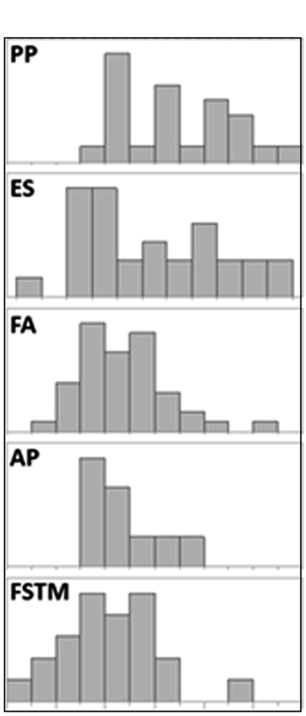
Table 1. Number of candidates and participants in advanced courses per geographical origin in the last 25 years

Origin	Candidates				Participants				% Acceptance	
CIHEAM	25,822		88.1%		8,166		86.6%		32%	
non-EU		***18,218***		***71%***		***4,214***		***52%***		***23%***
Spain		*5,386*		*21%*		*2,826*		*35%*		*52%*
Other EU		*2,218*		*9%*		*1,126*		*14%*		*51%*
Other Med	807		2.8%		252		2.7%		31%	
Other EU	466		1.6%		278		2.9%		60%	
non-EU	81		0.3%		35		0.4%		43%	
Latin-America	1,294		4.4%		501		5.3%		39%	
Others	828		2.8%		202		2.1%		24%	
Total	**29,298 from 140 countries**				**9,43 from 130 countries**				**32%**	

As there is a fixed number of places on every course, the relative interest of the CIHEAM-IAMZ course catalogue must be based on the (relative) number of applications received. Overall increased significantly in the first five years of the programme and has remained constant at a rate of around 3.5 candidates per place (Fig 6A). However, with the onset of the economic crisis, the number of self-supported candidates has decreased. In order to assess the relative interest of the various study areas, the number of applications per country and per area of study was analysed for the last 12 years, when the current IAMZ structure was established (Fig 6B). Overall demand was higher for Plant Production (PP) and Environmental Sciences (ES) whereas Fisheries and Aquaculture (FA) and Animal Production (AP) consistently showed lower demand, most probably due to their relatively smaller target audiences. Demand was more inconsistent for PP and ES (Fig 6B,C), which seem to be more mature disciplines compared to the others where some courses spark great interest, whereas others are much less demanded. This ratio is not uniformly distributed and the number of applications varies greatly from one course to another (Fig 6B,C).

Fig 7 is a biplot showing the relative interest of professionals of the various CIHEAM countries in the courses organised in the five CIHEAM study areas. We have used the data for the number of average applications organised per country and thematic discipline corresponding to the last 12 years, once the Fisheries & Aquaculture area had been formally established. It is noteworthy that this analysis has been carried out with country-standardised data. Therefore, rather than the absolute demand, this analysis can show the relative demand for advanced postgraduate training across the Mediterranean region. Analysing the magnitude of the vectors on the graph corresponding to each discipline, courses organised in Animal and Plant Production (AP and PV), are nearer the origin, which appears to illustrate uniform interest across the different CIHEAM countries. However, demand for FA, ES and FSTM courses vary more across countries. In particular, professionals from EU CIHEAM countries have a greater relative demand for FA, whereas non-EU CIHEAM professionals are relatively more interested in FSTM and ES. Four countries showed particular interest in some specific disciplines: French and Greek professionals have a small number of applications in absolute terms, but in relative terms they are more specifically interested in FA than FSTM, unlike Albania and Lebanon that show the opposite trend.





C

Area of Study	Mean	Tukey's HSD	n	min	Max	s
Plant Production	4.34	a	24	2.7	6.6	1.13
Environ. Sci	4.12	a	30	1.8	6.7	1.37
Fish & Aquaculture	3.33	b	43	1.8	6.0	0.88
Animal Production	3.33	b	28	2.5	4.8	0.69
Food Sci Techn & Marketing	3.00	b	23	1.3	5.6	1.00
Total	**3.66**		**148**	**1.3**	**6.7**	**1.12**

Fig. 6. Number of candidates per participant in advanced courses organised by study area in the 25 years (A). Distribution (B) and statistical comparison across study areas (C).

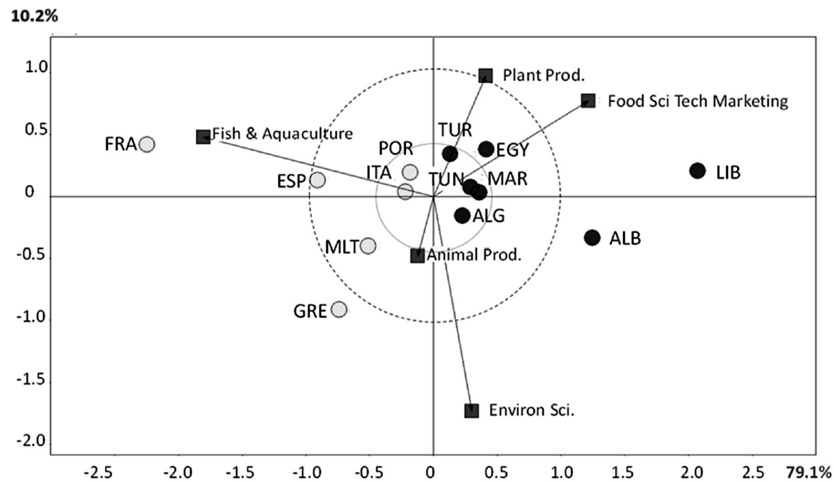


Fig. 7. Biplot of the number of applicants to advanced courses for professionals of the various CIHEAM countries in courses organised in the five IAMZ-CIHEAM study areas.

III – Conclusions

IAMZ's training system depends entirely on external lecturers and collaborating institutions. This is a strength as far as flexibility and diversity of topics is concerned, but dependence on external collaborations is also a weakness. Short duration advanced courses for professionals are an effective instrument of international cooperation, built on synergies with partner institutions, and better serve nowadays the original CIHEAM's mission of providing "Complementary Education". The large percentage of courses co-organised with international organisations, and the fact that many international institutions are seeking synergies for advanced training, shows that there is a large, unsatisfied demand for this type of advanced training. They arouse interest from both EU and Non-EU CIHEAM professionals and from elsewhere and, being of short duration, are particularly attractive to professionals from the private sector. They compete less with national higher education institutions. They are particularly well adapted to new training subject matters and tools and to IAMZ´s flexible administrative system. However, particularly when compared with the CIHEAM Master of Science, the international cooperation returns of these short duration courses are lower. In one or two weeks participants do not identify themselves with the institution and do not build close cooperative links between research units and visiting trainees. They are relatively expensive, with higher costs per time unit than in the Masters. Logistically they are quite complex as many people are deployed for just a few days.

Conference Programme

Conference Programme

Sunday 14 June

20:00 – 22:00	**Registration and welcome reception**

Day 1 – Monday 15 June

8:30 – 9:00	**Registration and documentation**
9:00 – 9:45	**OPENING SESSION**
9:00 – 9:05	*Masum BURAK. President of the Governing Board, International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM)*
9:05 – 9:10	*Ilan CHET. Deputy Secretary General for High Education and Research, Union for the Mediterranean (UfM)*
9:10 – 9:15	*Simon HEATH. Secretary General, Association for European Life Science Universities (ICA); Global Confederation of Higher Education Associations for Agricultural and Life Sciences (GCHERA)*
9:15 – 9:20	*Manuel J. LÓPEZ PÉREZ. President of the Conference of Rectors of Spanish Universities (CRUE). Rector, University of Zaragoza (Spain)*
9:20 – 9:35	**Presentation of the OECD Co-operative Research Programme on Biological Resource Management for Sustainable Agricultural Systems** *Rafael BLASCO. Scientific Advisory Board of the OECD Co-operative Research Programme on Biological Resource Management for Sustainable Agricultural Systems. Department of Biotechnology, INIA (Spain)*
9:35 – 9:45	**Presentation of the Conference** *Ervin BALAZS. Director, Centre for Agricultural Research at Martonvásár; Hungarian Academy of Sciences (Hungary)*
9:45 – 14:30	**SESSION I: CHALLENGES FOR AGRICULTURE IN THE XXI CENTURY** *Chairperson: Ilan CHET (UfM)*
9:45 – 10:30	**Agriculture in the XXI Century** *Catherine MOREDDU. OECD Trade and Agriculture Directorate*
10:30 – 11:00	*Coffee break*
11:00 – 11:30	**Main drivers in agricultural research and education to secure food supply and assure sustainability** *Inés MINGUEZ. Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM). Technical University of Madrid (UPM) (Spain)*
11:30 – 12:00	**Developing sustainability competence and 21st century capacities through Transformative Agricultural Education** *Arjen WALS. UNESCO Chair Social Learning Sustainable Development. Wageningen University (The Netherlands)*
12:00 – 12:30	**Ethical issues in agricultural production and education** *David KNAUFT. University of Georgia (USA)*
12:30 – 14:00	***Lunch***
14:00 – 14:30	**Student view: Attractiveness and employability** *Lisanne MEULENDIJKS. Vice-President of Communication, International Association of Agricultural Students (IAAS) (Belgium)*

Day 1 – Monday 15 June (cont.)

14:30 – 17:15	**SESSION II: ARE CURRENT AGRICULTURAL EDUCATIONAL MODELS SUITABLE TO MEET GLOBAL CHALLENGES?** *Chairperson: Masum BURAK (CIHEAM)*
14:30 – 14:45	**Case studies: Asia** *Shuichi ASANUMA. International Cooperation Center for Agricultural Research, Nagoya University (Japan)*
14:50 – 15:05	**Case studies: Oceania** *Holger MEINKE. Director of Tasmanian Institute of Agriculture, University of Tasmania (Australia)*
15:10 – 15:25	**Case studies: Latin America** *José A. ZAGLUL. President of the Earth University (Costa Rica)*
15:30 – 15:45	**Case studies: North America** *John KENNELLY. President, Global Confederation of Higher Education Associations for Agricultural and Life Sciences (GCHERA) (Canada)*
15:50 – 16:15	*Coffee break*
16:15 – 16:30	**Case studies: Europe 1** *Astrid BALLESTA. Member of ICA Board. Vice-Rector for International Relations and Cooperation, University of Lleida (Spain)*
16:35 – 16:50	**Case studies: Europe 2** *Piotr STYPINSKI. Warsaw Agricultural University (Poland)*
16:55 – 17:10	**Case studies: Northern African Countries** *Elies HAMZA. Director, Institut National Agronomique de Tunisie (INAT); Institution de la Recherche et de l'Enseignement Supérieur Agricoles (IRESA) (Tunisia)*
17:15 – 18:45	**General Discussion: Agricultural Core Curricula for BS + MSc + PhD cycles: Signposts for the future** *Facilitators: Maria NAVARRO (University of Georgia, USA), Simon HEATH (ICA, GCHERA)*
18:45	*Transportation to Zaragoza city (bus)*

Day 2 – Tuesday 16 June

9:00 – 15:00	**SESSION III: ADDRESSING THE NEEDS AND CHALLENGES FOR INNOVATION IN AGRICULTURAL CURRICULA** *Chairpersons: John KENNELLY (GCHERA), Guanghong ZHOU (Nanjing Agricultural University)*
9:00 – 9:45	**Non-traditional educational models** *Asha KANWAR. President and CEO, Commonwealth of Learning (Canada)*
9:45 – 10:15	**Needs for inclusion of technology transfer skills in curricula** *Ilan CHET. Union for the Mediterranean (UfM)*
10:15 – 10:45	**Recognition of traditional knowledge and innovative developments in agricultural higher education** *Ervin BALAZS. Centre for Agricultural Research, Hungarian Academy of Sciences (Hungary)*
10:45 – 11:15	*Coffee break*
11:15 – 11:45	**Requirements of the private sector in agricultural higher education** *Xavier LEPRINCE. SYNGENTA (Switzerland)*
11:45 – 12:15	**Needs and involvement of the public sector in higher education in emergent economies** *Said OUATTAR. Director, Institut Agronomique et Vétérinaire Hassan II (Morocco)*
12:15 – 12:45	**Developing the Industry Ready Graduate** *Greg ROWSELL. Dean of Engineering, Harper Adams University (UK)*
12:45 – 14:00	***Lunch***
14:00 – 14:30	**Role of new biotechnologies in agricultural curricula** *Antonio MOLINA. School of Agricultural, Food and Biosystem Engineering, Technical University of Madrid (UPM) (Spain)*
14:30 – 15:00	**Role of quality assurance and program accreditation in supporting development of innovative agricultural curricula** *Glen C. SHINN. Texas A&M University (USA)*
15:00 – 15:30	*Coffee break*
15:30 – 17:00	**General Discussion: Delivering the agricultural professionals with the knowledge, competences and skills required for a career in the XXI century** **(This session builds on the outcomes of Session II)** *Facilitators: Maria NAVARRO (University of Georgia, USA), Simon HEATH (ICA, GCHERA)*
17:00	*Transportation to Zaragoza city (bus)*
17:30 – 20:00	*Optional guided tour of Zaragoza*
21:00	***Dinner***

Day 3 – Wednesday 17 June

8:45 – 11.15	**SESSION IV: GLOBALIZATION AND INTERNATIONAL ALLIANCES** *Chairperson: Ian MAW (Association of Public and Land-grant Universities, USA)*
8:45 – 9:15	**Chinese Higher Education in Agricultural Science: Coping with challenges through transformative models** *Guanghong ZHOU. President of Nanjing Agricultural University (China)*
9:15 – 9:45	**Private enterprise commitment to higher education: The Universitas-Banco de Santander model** *Salvador MEDINA. Senior Vice-President of Banco Santander, Santander Universities Global Division (Spain)*
9:45 – 10:15	**Joint degrees: The future for agricultural higher education in the EU?** *Guido Van HUYLENBROECK. President of ICA. Dean, Faculty of Bioscience Engineering, Ghent University (Belgium)*
10:15 – 10:45	**USDA's vision on addressing current and future agricultural workforce needs in meeting societal challenges** *Muquarrab A. QURESHI. Deputy Director, Institute of Youth, Family and Community; USDA-National Institute of Food and Agriculture (USA)*
10:45 – 11:15	**An international cooperative model: CIHEAM-IAMZ training activities** *Ignacio ROMAGOSA. Director, Mediterranean Agronomic Institute of Zaragoza (Spain); CIHEAM*
11:15 – 11:45	*Coffee break*
11:45 – 12:30	**Final General Discussion** *Facilitators: Maria NAVARRO (University of Georgia, USA),* *Simon HEATH (ICA, GCHERA)*
12:30 – 12:45	**Concluding Remarks** *Conference conveners*
12:45 – 13:45	***Lunch***
14:00	*Transportation to Zaragoza railroad station & city (bus)*

Language: Main Conference language will be English, and simultaneous interpretation into French and Spanish will be provided.

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OPTIONS méditerranéennes

SERIES A: Mediterranean Seminars
2015 – Number 113

Agricultural Higher Education in the 21st Century

A global challenge in knowledge transfer to meet world demands for food security and sustainability

Edited by:
I. Romagosa, M. Navarro, S. Heath and A. López-Francos

In the forthcoming decades we will have to double food production on less land per capita, with less water, often under limiting and highly variable environmental conditions, and assuring the sustainability of the agro-ecosystems.

Agricultural Higher Education will undoubtedly contribute to fulfill these requirements, but for this it has to undergo profound changes. The challenges consist in attracting younger generations to study agriculture and life sciences, and in finding a way to complement classical agricultural education with new and emerging techniques. Education should motivate and enable graduates to work towards sustainable agricultural development in complex socio-economic and environmental contexts.

The International Conference "Agricultural Higher Education in the 21st Century - A global challenge in knowledge transfer to meet world demands for food security and sustainability" was held in Zaragoza (Spain) from 15 to 17 June 2015. It was organised by the Mediterranean Agronomic Institute of Zaragoza of the International Centre of Advanced Mediterranean Agronomic Studies (IAMZ-CIHEAM), the Union for the Mediterranean (UfM), the Association for European Life Science Universities (ICA), the Global Confederation of Higher Education Associations for Agricultural and Life Sciences (GCHERA) and the Centre for Agricultural Research of the Hungarian Academy of Science, with the collaboration of the OECD. The Conference convened top-level experts from different areas of the world to discuss and propose recommendations for the future development of curricula in Agriculture and Life Sciences to face current global challenges for food production.

This issue of Options Méditerranéennes publishes de Proceedings of the Conference including a summary report on the Conference and its conclusions, and 22 articles by the invited speakers, structured in 4 sections: (I) Challenges for agriculture in the XXI century; (II) Are current agricultural educational models suitable to meet global challenges?; (III) Addressing the needs and challenges for innovation in agricultural curricula; and (IV) Globalisation and international alliances.

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