

Paths for world-class universities in agricultural science

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Abstract The top-ranking world-class universities in agricultural science denote those universities which are globally popular with agriculture-related subjects. The paper synthesizes the results of three different ranking scales (NTU, QS and ARWU) of top 50 universities in agriculture subject in 2013. The overlapped parts have been synchronized to derive the following four classifications: A (agricultural universities amalgamated with others to be an agricultural comprehensive university), R (agricultural universities renamed to be a comprehensive university), M (agricultural universities merged into other units to form or to be a part of a comprehensive university) and C (comprehensive university's agricultural colleges or departments all the time). The following conclusions can be drawn: the majority (up to 94 %) of these universities are comprehensive ones (combination of R, M and C), and only 6 % of them are purely named agricultural universities; merging, renaming and comprehending are the three paths of agricultural universities' development; and to be a world-class university, it is necessary to have more than 9 ESI 1 % advantage subjects among the following: Plant and Animal Science, Environmental Science/Ecology, Biology and Biochemistry, Clinical Medicine, Chemistry, Engineering, Agricultural Sciences, Social Sciences/General, Molecular Biology and Genetics, Pharmacology and Toxicology and Geosciences. It would be possible for specialized universities to be world-class universities in their fields by being a major concentration of teaching and research as well as extending other subjects through merging and renaming.

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Introduction

Generally speaking, 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 by established institutions in UK, USA and much of Western continental Europe. The original model can be traced back to the middle ages. At that time, the earliest European universities offered a broad range of subjects as they could manage. The second model refers to the institution which specializes in one broad field. France pioneered the model since it established *Grandes écoles* in 1791, and the Soviet Union actually became the most influential proponent by using this model. It was also adopted in China, Vietnam and several other socialist countries. However, since the last quarter of the twentieth century, especially with the collapse of Soviet Union in 1991, the specialized universities reconsidered their development orientations. Meanwhile, the world university's rankings have accelerated universities in reviewing their visions to include measures of volume as well as indicators of quality. For big universities, they are more likely to be comprehensive, while few specialized universities have high world ranks. This paper therefore addresses this conflict.

In the 2000s, many countries joined the global pursuit to build a world-class university in the knowledge society (Shin 2013). Many countries are now creating world-class universities (WCUs), as essential parts of their higher education reforms (Lee 2013). For instance, in China, there are at least 33 out of 72 specialized universities attached to the Ministry of Education. They concentrate on the following fields of study: agriculture, forestry, engineering, industry, etc. Nearly all of their visions are orientated with WCUs in specialized fields. In the agricultural field, China Agricultural University, Nanjing Agricultural University, etc., have fixed their goals as world-class agricultural universities.

The paradox of the world-class university, however, is that everyone wants one, no one knows what it is, and no one knows how to get one (Altbach 2004). Nevertheless, in an attempt to propose a more manageable definition of WCUs, three complementary sets of factors can be found in most top universities; the factors are a high concentration of talent-abundant resources to offer a rich learning environment and conduct advanced research, and favorable governance features that encourage strategic vision, innovation and flexibility, and enable institutions to make decisions and manage resources without being encumbered by bureaucracy (Salmi 2009).

Then, what are the paths for WCUs in agricultural science? Especially for agricultural universities, which model should they undertake in order to be global top ones in the agricultural science field? The research therefore synthesizes the results of three ranking scales through an empirical study. The first step was to search for the models through overlapped results of three university rankings as a sample study. Secondly, through tracing back the universities' histories, four classified clusters (A, R, M and C) were identified. Thirdly, the academic units of these universities were analyzed to find the characteristics of academic structures. Finally, a search into the ESI 1 % citation rankings was done to address the overlapped areas of the sampled universities.

Searching for the global top universities in agricultural science

Currently, there are more than fifteen international rankings in the world (Marope et al. 2013). Among these, the study chose the three prominent ranks of the several available. These are ARWU (Academic Ranking of World Universities) prepared by Shanghai Jiao Tong University, QS World University Rankings by Quacquarelli Symonds and NTU Ranking by National Taiwan University. Though those who make it to the top in any of these rankings would perhaps claim that the accomplishment is well deserving (Barbara and Bjorns, 2009) and despite the methodological limitations of any ranking exercise (Salmi and Saroyan 2007), WCUs are recognized in part for their superior outputs, for example, research, teaching, employability, facilities, internationalization, innovation, and specialist. Many universities therefore benefit from these ranks as an indication of their educational and research progress (Aguillo et al. 2010). Some countries have national ranks, but some believe that such ranks are biased by national preferences (Oswald 2010; Baty 2010). The findings of this study do not support these statements, as seen in Table 1 below. Though the QS rank was developed in the UK, it has included many universities from China and Japan in its top 200 universities. NTU, which was modeled in Taiwan, has only ranked the University of Taiwan. ARWU, which was initiated in China, ranks a few universities from China and Hongkong in the top 200 universities in the world.

Table 2 shows the ranks in agricultural science of the universities which are included in all 3 agricultural science ranks in 2013. Higher education policy-making displays great ambition. The Swedish 1977 higher education reform is the most ambitious attempt so far to implement the comprehensive university (Lane et al. 1982). China's "Project 211" established in 1993 and "Project 985" established 1998 illustrate that China has made a great steps to set up its WCUs. Another example is the recent formation of the C9 by the nine Chinese universities which were selected for "Project 985," in the image of the Association of American Universities, the Russell Group in the UK and the Group of Eight in Australia. These can be seen as China's drive to create WCUs. The Chinese experience may shed some light on the worldwide movement to build WCUs (Li 2012). International rankings in their present form only cover a small percentage of the world's 17,500 universities, between 1 and 3 % (200–500 universities), with little consideration given to the rest (Andrejs 2013).

Therefore, to be considered as a world-class university in agricultural science, a university needs to be ranked among top 500 universities and in the top 50 in agriculture. This can be simplified as "double 5 ranks." Based on these criteria, the universities in Tables 2 and 3 can be recognized as the preliminary models of world-class agriculture-related universities. These universities include Texas A&M University, Swedish University of Agricultural Sciences and China Agricultural University.

USA has the best universities with agricultural subjects in the world (see Table 4). These universities have led innovation and have always topped previous ranks. USA agricultural universities have formed the foundation for the USA's economic prosperity.

Classification of world-class universities in agricultural science

The path to developing WCUs involves developing an integrated system of teaching, research and technology-oriented institutions, which feed into and support a few centers of excellence. Salmi (2009) noted this may be done by upgrading existing institutions,

Table 1 University ranking methodology and indicators

Ranking name	Publisher/commencing Year	Indicators and weight	Website
QS	Quaquarelli Symonds, 2004	Academic reputation, 40 % Employer reputation, 10 % Student-to-faculty ratio, 20 % Citations per faculty, 20 % International faculty ratio, 5 % International student ratio, 5 %	http://www.topuniversities.com/university-rankings-articles/world-university-rankings/qs-world-university-rankings-methodology
ARWU	Institute of Higher Education of Shanghai Jiao Tong University, 2003	Alumni (Alumni with Nobel and Field Medals), 10 % Award (Nobel and Field Medal winners), 20 % HiCi (Researchers cited by Thomson Scientific), 20 % N&S (articles published in <i>Nature</i> and <i>Science</i>), 20 % PUB (articles indexed in SCI and SSCI), 20 % PCP (faculty average score in above 5 items), 10 %	http://www.shanghairanking.com/aboutarwu.html
NTU	National Taiwan University, 2007	Research productivity (articles etc.), 40 % Research impact (Article citations etc.), 30 % Research excellence (Highly cited papers etc.), 30 %	http://nturanking.lis.ntu.edu.tw/Default.aspx

Table 2 Leading universities by their ranks in agriculture science

No.	Names of universities	NTU-Agriculture	QS agriculture-forestry	ARWU life-agriculture Sci.
1	Cornell University	3	3	16
2	University of California, Davis	2	1	20
3	University of Wisconsin-Madison	6	4	13
4	University of California, Berkeley	5	11=	14
5	Wageningen University	1	2	32
6	The University of Queensland	12	7	40
7	University of Minnesota	7	26	34
8	University of Florida	4	23	41
9	University of British Columbia	12	27=	35
10	Michigan State University	9	16	51–75
11	University of Washington(Seattle)	20	51–100	5
12	Kyoto University	45	17=	17
13	The University of Tokyo	25	19=	37
14	University of Copenhagen	10	21=	51–75
15	Pennsylvania State University	28	9	51–75
16	Ghent University	8	31	51–75
17	Yale University	59	27=	8
18	Oregon State University	15	8	76–100
19	Duke University	23	51–100	30
20	Colorado State University	30	24=	51–75
21	The University of Georgia	17	38	51–75
22	The University of Western Australia	40	51–100	26
23	Australian National University	43	30	51–75
24	The University of Melbourne	46	42	38
25	Ohio State University	39	11=	76–100
26	University of Toronto	35	51–100	47
27	University of Illinois at Urbana–Champaign	18	17=	101–150
28	McGill University	70	46	23
29	North Carolina State University	24	14=	101–150
30	Texas A&M University	33	5	101–150
31	Purdue University	36	6	101–150
32	Iowa State University	32	10	101–150
33	University of Helsinki	22	51–100	76–100
34	Swedish University of Agricultural Sciences	14	40	101–150
35	University of Guelph	27	32	101–150
36	University of Alberta	40	51–100	76–100
37	University of California, Riverside	47	51–100	76–100
38	The University of Sydney	51	49	76–100
39	University of Arizona	31	51–100	101–150
40	Swiss Federal Institute of Technology	19	14=	151–200
41	The University of Adelaide	63	29	101–150
42	The University of Nottingham	104	50=	48

Table 2 continued

No.	Names of universities	NTU-Agriculture	QS agriculture-forestry	ARWU life-agriculture Sci.
43	Washington State University	50	51–100	101–150
44	University of Massachusetts, Amherst	68	44	101–150
45	Aarhus University	16	51–100	151–200
46	National Taiwan University (NTU)	75	51–100	101–150
47	University of Barcelona	85	51–100	101–150
48	China Agricultural University	42	51–100	151–200
49	Universität Freiburg	152	51–100	51–75
50	Laval University	106	51–100	101–150

Data retrieved on January 15–17, 2015, from National Taiwan University Ranking (2013)

<http://nturanking.lis.ntu.edu.tw/Default.aspx>, academic ranking of World Universities (2013)

<http://www.shanghairanking.com/ARWU2013.html> and QS Top Universities (2013)

<http://www.topuniversities.com/university-rankings/world-university-rankings/>

merging institutions to concentrate strengths, creating new institutions, or by combinations of these strategies.

Tracing back to their histories, we can easily find that merging, renaming and comprehending are the three characteristics of world-class universities in agricultural science (as shown in Table 5).

According to their characteristics of evolution, these 50 universities in agricultural science can be classified into four types: A, R, M and C.

- (1) Type A Agricultural Universities amalgamated with others to be an agricultural comprehensive university.
- (2) Type R Agricultural Universities re-named to be a comprehensive university.
- (3) Type M Agricultural Universities merged into other units to form or to be a part of a comprehensive university.
- (4) Type C Comprehensive university's agricultural colleges or department all the time.

There are only three universities in type A, making up 6 %. Both type R and type M share 34 % of the total. The majority of these universities are type C, which takes up to 60 % of the total, as shown in Fig. 1.

The results in Fig. 1 above concur with Salmi and Liu (2011) that WCUs are mostly comprehensive with sufficient budgets. Goedegebuure and Meek (1991) argue that large institutions joining the merger process bring in scarce resources from the government, as well as diversifying to cover as many fields as possible. This study is consistent with the point that university merging is becoming an increasingly popular restructuring strategy for promoting efficiency, effectiveness, economy and competition in the higher education sector (Mok 2005). This strategy is especially seen in the WCUs in agricultural science, which resulted in their agriculture-related subjects being reinforced and upgraded.

As indicated in Fig. 1, 14 % of these universities changed their names. "The original reason for these universities to change their names perhaps is in order to change and refocus their identity, missions, and strategic visions to better serve students, prospective students, partners, and other external constituencies, as well as distinguish and differentiate

Table 3 Institutional ranks of universities which are ranked in agricultural science

No.	Names of Universities	Location	NTU	QS	ARWU
1	University of California, Berkeley	USA*	6	25	3
2	Yale University	USA	19	8	11
3	Cornell University	USA*	22	15	13
4	University of Toronto	Canada	8	17	28
5	The University of Tokyo	Japan	17	32	21
6	Duke University	USA	17	23	31
7	University of Wisconsin-Madison	USA*	21	37	19
8	Kyoto University	Japan	33	35	26
9	McGill University	Canada	34	21	58
10	University of British Columbia	Canada	27	49	40
11	University of Illinois at Urbana-Champaign	USA*	39	56	25
12	University of Copenhagen	Denmark	36	45	42
13	The University of Melbourne	Australia	38	31	54
14	University of Minnesota	USA*	23	102	29
15	Swiss Federal Institute of Technology	Swiss	42	12	101–150
16	University of California, Davis	USA*	29	85	47
17	The University of Sydney	Australia	51	38	97
18	Pennsylvania State University	USA*	46	107	54
19	Ohio State University	USA*	31	113	65
20	University of Helsinki	Finland	64	69	76
21	Purdue University	USA*	98	99	57
22	Aarhus University	Denmark	86	91	81
23	University of Washington(Seattle)	USA	4	59	201–300
24	Australian National University	Australia	177	27	66
25	University of Alberta	Canada	77	96	101–150
26	The University of Nottingham	UK	123	75	83
27	National Taiwan University	Taiwan	98	82	101–150
28	Ghent University	France	78	122	85
29	University of Florida	USA*	35	179	71
30	Texas A&M University	USA*	80	153	101–150
31	The University of Western Australia	Australia	166	84	91
32	Universität Freiburg	Germany	140	102	100
33	University of Arizona	USA*	65	212	78
34	Michigan State University	USA*	93	171	92
35	Wageningen University	Netherlands	162	150	101–150
36	University of Barcelona	Spain	89	178	201–300
37	University of Massachusetts, Amherst	USA*	176	261	101–150
38	The University of Adelaide	Australia	246	104	201–300
39	University of California, Riverside	USA*	193	268	101–150
40	Iowa State University	USA*	148	321	151–200
41	North Carolina State University	USA*	202	304	151–200
42	The University of Georgia	USA*	217	411–420	101–150
43	Oregon State University	USA*	251	401–410	101–150

Table 3 continued

No.	Names of Universities	Location	NTU	QS	ARWU
44	Laval University	Canada	235	201–300	329
45	Colorado State University	USA*	237	394	151–200
46	The University of Queensland	Australia	67	701+	85
47	Washington State University	USA*	289	366	201–300
48	University of Guelph	Canada	362	461–470	201–300
49	Swedish University of Agricultural Sciences	Sweden	375	–	201–300
50	China Agricultural University	China	494	–	301–400

Data retrieved on January 15–17, 2015, from National Taiwan University Ranking (2013) on <http://nturanking.lis.ntu.edu.tw/Default.aspx>, Academic Ranking of World Universities (2013) on <http://www.shanghairanking.com/ARWU2013.html> and QS Top Universities (2013) on <http://www.topuniversities.com/university-rankings/world-university-rankings/>
University marked with “*” means land-grant University

Table 4 Number of universities in each continent which are ranked in the top 500 which have agriculture ranked in the top 50 in 2013

Continents with universities in ranking	QS	ARWU	NTU
North America	57	90	–
South America	24	–	–
Europe	61	89	–
Africa	4	1	–
Asia	40	28	–
Oceania	14	–	–
Total	200	200	–

Data retrieved on February 20–25, 2015, from ARWU (<http://www.shanghairanking.com/ARWU-FIELD-Statistics-2014.html#1>)
QS (<http://www.topuniversities.com/university-rankings/university-subject-rankings/2014/agricultural>)

themselves in this growing and evolving marketplace” (Moorer 2007). Either merging or renaming of a university will result in its comprehensiveness (integration). Comprehensiveness occurred in all of the 50 universities named above perhaps due to the globalization, which accelerates higher education restructuring itself along the line of marketization, corporatization and privatization (Mok 2002).

Even these universities which have had “agriculture” in their name for much of their history, Texas A&M University, Swedish University of Agricultural Sciences and China Agricultural University, have merged with other institutions and have extended their subjects to become comprehensive or quasi-comprehensive universities, with each of them having lots of colleges or departments, as shown in Table 6.

Most of the top 50 universities in agricultural science globally have an academic unit such as a faculty, schools, college, center, department, institute in agriculture or/and life science and veterinary medicine (or science). Some have only one or two of the top-level

Table 5 The history of evolution for top 50 universities in agricultural science

University	History of Evolution (year)	Type
Texas A&M University	The Agricultural and Mechanical College of Texas (1871) → Texas A&M separate system (1948) → Texas A&M University in 1963. Many others joined in, for example, Texas A&I University (1989), West Texas State University (1990), etc. Now, the university system provides oversight and leadership for 11 universities	A
Swedish University of Agricultural Sciences	Agricultural Institute (1848) → the Royal Swedish Academy of Agriculture(1862) → Agricultural College(1932) → Swedish University of Agricultural Sciences(1977) by combining other two existing separate colleges the veterinary college (1775) and the college of forestry (1762)	
China Agricultural University	Beijing Agricultural University (1950) → China Agricultural University (1995) by merging with Beijing University of Agricultural Engineering	
Michigan State University	Agricultural school(1850) → the Agricultural College of the State of Michigan(1855) → State Agricultural College(1861) → Michigan Agricultural College(1909) → Michigan State College of Agriculture and Applied Science(1925) → Michigan State University of Agriculture and Applied Science(1955) → Michigan State University (1964)	R
Oregon State University	Corvallis Academy(1856) → Corvallis College formally incorporated by members of the Freemasons(1858) → Corvallis State Agricultural College(1868) → Oregon Agricultural College(1890) → Oregon State College (1937) → Oregon State University(1961)	
Colorado State University	Colorado Agricultural College (1870) → The Colorado State College of Agriculture and Mechanic Arts (1935) → Colorado State University (1957)	
Ohio State University	Ohio Agricultural and Mechanical College (1862) → The Ohio State University (1878)	
Iowa State University	Iowa Agricultural College (1858) → Iowa State College of Agricultural and Mechanic Arts(1898) → Iowa State University of Science and Technology (i.e., "Iowa State University")(1959)	
Washington State University	Washington Agricultural College and School of Science (1892) → State College of Washington (1905) → Washington State University(1959)	
University of Massachusetts, Amherst	The Massachusetts Agricultural College (1863) → Massachusetts State College(1931) → University of Massachusetts(1947)	
Wageningen University	Wageningen Agricultural College (1876) → National Higher College of Agriculture, Horticulture and Forestry(1904) → National Agricultural College(1918) → the Agricultural University(1986) → The Wageningen University by merging with the DLO Research Institutes and the Institutes for Applied Research(1997)	M
Pennsylvania State University	Farmers' High School of Pennsylvania (1855) → Agricultural College of Pennsylvania(1862) → Pennsylvania State College(1874) → The Pennsylvania State University(1953);Pennsylvania College of Technology and Dickinson School of Law joined in 1989 and 2000	

Table 5 continued

University	History of Evolution (year)	Type
University of Guelph	The Ontario School of Agriculture (1874) → The Ontario Agricultural College (1880) → Amalgamated with The Ontario Veterinary College (1862) and The Macdonald Institute (1903) to be the single body of the University of Guelph (1964)	
University of California, Davis	University Farm(1891) → The University Farm School(1909) → The Northern Branch of the College of Agriculture(1922) → the College of Agriculture at Davis(1938) → The College of Agriculture at Davis separates from Berkeley(1952) → The Regents designate UC Davis as the seventh general campus in the University of California system(1959)	
University of California, Berkeley	By a merger of two fledgling institutions—the College of California and the Agricultural, Mining, and Mechanical Arts College, the state organized the University of California in 1868 and 1952, UC departure	
The University of Queensland	The Queensland Agricultural College(1897)merged into the University of Queensland In 1990.	
University of Florida	The Florida Agricultural College was consolidated with The state-funded East Florida Seminary moved to Gainesville in the 1860s and became the University of Florida in 1905	
University of Copenhagen	The Royal Veterinary and Agricultural University (1856) and The Danish University of Pharmaceutical Sciences merged with The University of Copenhagen in 2007	
North Carolina State University	North Carolina College of Agriculture and Mechanic Arts(1887) → North Carolina State College of Agriculture and Engineering(NC State, 1918) → The conglomeration of the North Carolina State College of Agriculture and Engineering, the University of North Carolina and the Woman's College became the University of North Carolina in 1931 and changed its name to North Carolina State University in 1962	
University of California, Riverside	The Citrus Experiment Station in Riverside of California (1907) → became one campus of University of California system (1959)	
Cornell University	Cornell University(1865) → Main Campus(West, College Town and North Campus), NYC Tech Campus, Doha Education Cit, etc.	C
University of Wisconsin-Madison	University of Wisconsin-Madison (1848) → University of Wisconsin system (1971) including more than ten universities, such as UW-Madison, UW-Eau Claire.	
University of Minnesota(Twin Cities)	The University of Minnesota, Twin Cities (1851) → University of Minnesota System with five campuses: Twin Cities, Duluth, Morris, Crookston, and Rochester	
University of British Columbia	BC University Act (1908) → McGill University College of British Columbia (1910) → University of British Columbia (1915) → Okanagan University College joined to be BC University Okanagan (2004)	
University of Washington(Seattle)	University of Washington (1861) → three campuses: Seattle, Bothell, and Tacoma	

Table 5 continued

University	History of Evolution (year)	Type
Kyoto University	The Third Higher School (1869) → Kyoto Imperial University (1897) → Kyoto University by merging the Kyoto Imperial University and the Third Higher School(1947) along with three campuses: Yoshida, Kyoto; Gokashō, Uji; and Katsura, Kyoto	
The University of Tokyo	Tokyo University (1977) by amalgamating older government schools for medicine and Western learning → Imperial University (1886) → Tokyo Imperial University (1897) → Tokyo University (1947)	
Ghent University	The state University of Ghent University (1817) → Ghent University (1991).	
Yale University	Collegiate School (1701) → Yale College (1718) → Yale University (1887).	
Duke University	Brown's Schoolhouse (1838) → Union Institute Academy(1841) → Normal College(1851) → Trinity College(1859) → Duke University (1924)	
The University of Georgia	The University of Georgia (1785) → merged the North Georgia College and the later became the University of North Georgia (2013)	
The University of Western Australia	The University of Western Australia (1911)	
Australian National University	Australian National University (1946)	
The University of Melbourne	The University of Melbourne (1853)	
University of Toronto	King's College(1827) → University of Toronto(1850)	
University of Illinois at Urbana-Champaign	The Illinois Industrial University(1867) → University of Illinois 1885 → University of Illinois at Urbana–Champaign(1982)	
McGill University	The Royal Institution for the Advancement of Learning (RIAL)(1801) → McGill College(1829) → McGill University (1885)	
Purdue University	Purdue University(1869)	
University of Helsinki	Royal Academy of Abo (1640) → Imperial Alexander University in Finland (1828) → University of Helsinki (1919).	
University of Alberta	University of Albert(1908) → Merger of Augustana University College (2004)	
The University of Sydney	The University of Sydney(1850)	
University of Arizona	The University of Arizona (1885)	
Swiss Federal Institute of Technology	Federal polytechnic school (1855) → Swiss Federal Institute of Technology (1911) → Since 1993 ETH Zürich, the EPFL, and four associated research institutes were joined and administered together as the ETH Domain.	
The University of Adelaide	The University of Adelaide (1874). Roseworthy Agricultural College (1883) amalgamated with the university in 1991	
The University of Nottingham	University College Nottingham (1881) → The University of Nottingham (1948)	
Aarhus University	University Studies in Jutland (1928) → Aarhus University (1933) → merged with HIH in Herning and DPU in Copenhagen (2006), Engineering College of Aarhus in Copenhagen (2012)	

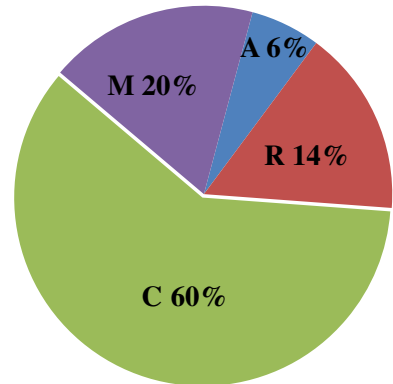
Table 5 continued

University	History of Evolution (year)	Type
National Taiwan University (NTU)	Taihoku Imperial University(1928) → National Taiwan University(1945)	
University of Barcelona	The University of Barcelona(1450)	
Universität Freiburg	Albrechts University(1457) → Albert Ludwigs University Freiburg (i.e., Universität Freiburg) (1820)	
Laval University	The Séminaire de Québec (1663) → Université Laval (1852)	

Data retrieved on February 20–25, 2015, from

ARWU (<http://www.shanghairanking.com/ARWU-FIELD-Statistics-2014.html#1>)

Fig. 1 Types of top 50 universities in agricultural science



units in forestry, natural resources, environmental science or food science, etc. It is important to note that some of the comprehensive universities have not established a top-level unit in an agriculture subject or field, but have a strong competitive advantage in agriculture, for example, University of Washington (Seattle), Duke University, Australian National University, University of Toronto, Swiss Federal Institute of Technology, University of Barcelona, Universität Freiburg, University of California, Berkeley, and University of Copenhagen. However, no evidence shows that the more comprehensive a university is, the more academic units it has or, the more comprehensive, the stronger its subjects even if becoming more comprehensive is a common trend of these universities.

ESI citation rankings of world-class universities in agricultural science

WCUs are essential in today's social, economic developments, and therefore, every country wants to have one (Altbach 2004). Global rankings of agricultural universities provide an effective and efficient way of projecting a world-class image of higher education and its relative impact on the country's economic development. Moed (2006) pointed out that journal publications are the prime vehicles for knowledge dissemination, even though publication cultures vary in different fields. Salmi (2009) argued that, "sciences are more international in their mode of publication while humanities and social

Table 6 Academic units of world top 50 universities in agricultural science

Type	University	Schools and Colleges	Data sources
A	Texas A&M University	12 Colleges/Units: Agriculture and Life Sciences; Veterinary Medicine and Biomedical Sciences, etc.	http://www.tamu.edu/about/departments.html#veterinary
	Swedish University of Agricultural Sciences	36 Department in 4 Faculties: Landscape Architecture, Horticulture and Crop Production Science; Forest Sciences; Natural Resources and Agricultural Sciences; Veterinary Medicine and Animal Science	http://www.slu.se/en/about-slu/locations-and-units/units/faculties-and-departments/
	China Agricultural University	14 Colleges: Agronomy and Biotechnology; Biology Science; Resources and Environmental Science; Animal Science and Technology; Veterinary Medicine; Food Science and Nutritional Engineering; Engineering, etc.	http://www.cau.edu.cn/col/col10227/index.html
R	Michigan State University	18 Colleges: Agriculture and Natural Resources; Veterinary Medicine	http://www.msu.edu/academics/colleges.html
	Oregon State University	A Graduate School and 12 colleges: Agricultural Sciences; Forestry; Veterinary Medicine; 15 Agricultural Experiment Stations, 35 county Extension offices	http://oregonstate.edu/main/academics
	Colorado State University	8 Colleges: Agricultural Sciences; Veterinary Medicine and Biomedical Sciences; Schools and Programs	http://www.colostate.edu/academics/
	Ohio State University	20 Colleges and Schools: Environmental and Natural Resources; Food, Agricultural, and Environmental Sciences; Veterinary Medicine, etc.	http://www.osu.edu/academics/a-z.html
	Iowa State University	8 Colleges: Agriculture and Life Sciences; Veterinary Medicine, etc.	http://web.iastate.edu/academics/
	Washington State University	10 Colleges: Agricultural, Human, and Natural Resource Sciences; Veterinary Medicine, etc.	http://about.wsu.edu/academics/
	University of Massachusetts, Amherst	12 Colleges and Schools: Agriculture, etc.	http://www.umass.edu/gateway/academics/schools-and-colleges
M	Wageningen University	5 Groups: Agrotechnology and Food Sciences, Animal Sciences, Environmental Sciences, Plant Sciences, Social Sciences. 6 graduate schools	http://www.wageningenur.nl/en/wageningen-university.htm
	Pennsylvania State University	14 distinct colleges IN the University Park campus: Agricultural Sciences, etc.	http://en.wikipedia.org/wiki/Pennsylvania_State_University#History
	University of Guelph	7 Colleges: Biological Science; Ontario Agricultural College; Ontario Veterinary College, etc.	http://www.uoguelph.ca/academics/

Table 6 continued

Type	University	Schools and Colleges	Data sources
	University of California, Davis	4 Undergraduate and graduate: Colleges of Agricultural and Environmental Sciences; Biological Sciences; 6 Professional Schools: Veterinary Medicine	http://www.ucdavis.edu/academics/index.html#colleges
	University of California, Berkeley	14 colleges and schools: School of Natural Resources, etc.	http://www.berkeley.edu/about/hist/academics
	The University of Queensland	Three campuses, 6 Faculties and 33 Schools: Agriculture and Food Sciences; Veterinary Science, etc.	http://www.uq.edu.au/departments/unit_types.html?type=5
	University of Florida	16 Colleges: Agricultural and Life Sciences; Veterinary Medicine	http://www.ufl.edu/academics/
	University of Copenhagen	6 Faculties: Health and Medical Sciences, etc.: Near 100 Departments, Schools, Centers, and Institutes	http://introduction.ku.dk/organization/faculties/
	North Carolina State University/	12 College; Agriculture and Life Sciences; Natural Resources; Veterinary; Medicine	http://www.ncsu.edu/academics/colleges
	University of California, Riverside	3 Colleges: Natural and Agricultural Sciences. 4 Schools; 6 Divisions: Agriculture and Natural Resources; Biomedical Sciences; Life Sciences	http://www.ucr.edu/academics/colleges.html
C	Cornell University	7 Undergraduate Colleges and Schools: Agriculture and Life Sciences, etc. 8 Graduate and Professional Colleges and Schools: Veterinary Medicine, etc.	http://www.cornell.edu/academics/colleges.cfm
	University of Wisconsin-Madison	22 Schools and Colleges: Agricultural and Life Sciences; Environmental Studies; Veterinary Medicine, etc.	http://www.wisc.edu/academics/
	University of Minnesota(Twin Cities)	.More than 5 Campuses. Twin Cities: 19 Colleges and Schools: Biological Sciences; Food, Agricultural, and Natural Resource Sciences; Veterinary Medicine, etc.	http://www1.umn.edu/twincities/academics-research/index.html#colleges
	University of British Columbia	27 Faculties and Schools at UBC's Vancouver Campus: Environmental Health; Forestry; Land and Food Systems, etc. 8 Faculties and Schools in UBC's Okanagan campus	http://www.ubc.ca/academics/
	University of Washington(Seattle)	Three campuses. Seattle's 16 Colleges and Schools: Environment	http://www.washington.edu/facultystaff/
	Kyoto University	10 Faculties: Agriculture, etc; 19 Graduate Schools: Agriculture; Bio-studies; Global Environmental Studies, etc.	http://www.kyoto-u.ac.jp/en/faculties_and_graduate
	The University of Tokyo	10 Faculties: Agriculture, etc; 15 Graduate Schools : Agricultural and Life Sciences, etc. 11 Institutes and 13 University-wide Centers	http://www.u-tokyo.ac.jp/en/about/organization/institutes.html

Table 6 continued

Type	University	Schools and Colleges	Data sources
	Ghent University	11 faculties, composed of more than 130 departments: Veterinary Medicine; Bio-science Engineering, etc.	http://en.wikipedia.org/wiki/Ghent_University
	Yale University.	Three major academic components. 12 Professional Schools: Forestry and Environmental Studies, etc.	http://www.yale.edu/about/index.html
	Duke University	4 Campus; 10 Colleges and Schools: Nicholas School of the Environment, etc.	http://duke.edu/
	The University of Georgia	18 Schools and Colleges: Agricultural and Environmental Sciences(1859); Forestry and Natural Resources; Veterinary, Medicine(1964), etc.	http://www.uga.edu/ ; http://en.wikipedia.org/wiki/University_of_Georgia
	The University of Western Australia	9 Faculties and 32 Schools: Agricultural and Resource Economics; Plant Biology, etc.	http://www.uwa.edu.au/study/faculties
	Australian National University	30 Schools in 7 Colleges: Medicine, Biology and Environment, etc.	http://about.anu.edu.au/governance-structure/university-structure/academic-structure
	The University of Melbourne	22 graduate schools in 11 Faculties: Land and Environment; Veterinary Science, etc.	http://www.unimelb.edu.au/
	University of Toronto	3 Campus. Besides, 7 Colleges, 20 Divisions/Faculties: Forestry, etc.	http://www.utoronto.ca/programs/divisions-faculties
	University of Illinois at Urbana-Champaign	17 Major Academic Units: Agricultural, Consumer and Environmental Sciences; Veterinary Medicine, etc.	http://illinois.edu/academics/academics.html
	McGill University	12 Schools, 13 Faculties: Agricultural and Environmental Sciences, etc.	http://www.mcgill.ca/faculties/
	Purdue University	13 Colleges and Schools: Agriculture; Veterinary Medicine, etc.	http://www.purdue.edu/purdue/about/colleges_schools.html
	University of Helsinki	4 Campus,12 Faculties:Agriculture and Forestry;Veterinary Medicine, etc.	http://www.helsinki.fi/units/index.html
	University of Alberta	20 Faculties and Departments: Agricultural, Life and Environmental Sciences, etc.	http://uofa.ualberta.ca/faculties-and-programs
	The University of Sydney	16 Faculties(including 70 schools and divisions): Agriculture and Environment; Veterinary Science, etc.	http://sydney.edu.au/about/faculties_schools.shtml
	University of Arizona	21 Colleges (or and 20 Schools): Agriculture and Life Sciences, etc.	http://www.arizona.edu/topics/colleges-schools
	Swiss Federal Institute of Technology	16 Departments and Competence Centers including the following fields: System-oriented Natural Sciences, etc.	https://www.ethz.ch/en/research/departments-and-competence-centres.html
	The University of Adelaide	5 Academic Faculties, 31 Schools, such as Agriculture, Food and Wine; Animal and Veterinary Sciences, etc.	http://www.adelaide.edu.au/departments/academic/
	The University of Nottingham	5 Faculties including 31 Departments: Life Sciences, Veterinary Medicine, and Science, etc.	http://www.nottingham.ac.uk/departments/byfaculty.aspx

Table 6 continued

Type	University	Schools and Colleges	Data sources
	Aarhus University	Six subject areas, including 28 departments, such as Agricultural Ecology, Animal Science, Bioscience, Environmental Science, etc.	http://www.au.dk/en/research/departments/
	National Taiwan University (NTU)	16 Academic Programs: Bio-Resources and Agriculture; Management; Life Science; Veterinary Medicine	http://www.ntu.edu.tw/engv4/academics/academics.html
	University of Barcelona	10 Faculties and ICE: Biology, Chemistry, etc.	http://www.ub.edu/web/ub/en/
	Universität Freiburg	Besides 18 research centers, 11 faculties: Biology; Environment and Natural Resources, etc.	http://www.uni-freiburg.de/forschung-en
	Laval University	17 faculties are covering all fields of study: Agriculture and Food Sciences; Forestry	http://www2.ulaval.ca/en/academics/faculties-departments-and-schools.html

sciences deal more with national issues.” Figure shows ESI % citation per paper ranking in agricultural sciences.

Most of the type R and type M universities follow up, with the ranges 9–14 and 8–16, respectively. Among the type A universities (with a range of 7–11), Swedish University of Agricultural Sciences is the most outstanding (see Fig. 2). As a matter of fact, it is at least a quasi-comprehensive university. Like the Swedish University of Agricultural Sciences, the China Agricultural University has comparatively few high-performing subjects. It is suggested that to become a world-class agricultural university, a university should have more than nine fields of study in the ESI 1 % citation rank. Usher and Savino (2006) summarized the indicators of world agricultural universities as encompassing six elements: beginning characteristics, learning inputs, learning outputs, final outcomes, research and reputations. They further noted that research and reputation play an important role in ranking, causing trends toward convergence. Due to this weakness, the emerging ranking systems mainly ARWU, QS and NTU developed regional and subject rankings in response to this type of criticism (Marginson 2009).

The comprehensive universities possess over 15 of total 22 subjects in ESI’s top 1 % (see Fig. 3).

As detailed in Fig. 4, the top 50 agricultural universities have the fields of Plant and Animal Science, Biology and Biochemistry and Environment/Ecology together with Clinical Medicine, Chemistry, Social Sciences/General, Agricultural Sciences, Engineering, Molecular Biology and Genetics, Pharmacology and Toxicology and Geosciences. The eleven fields take up over 90 % of the ESI’s top 1 % categories of subjects. The other six fields (Physics, Material Sciences, Neuroscience and Behavior, Immunology, Microbiology, as well as Psychiatry and Psychology) take up over 80 % of the total. This is the first layer of field groups world agricultural universities can pursue. It is easy to understand that these fields have a close link to the agricultural sciences. The least portion of fields is located in Computer Science, Space Science, Mathematics, Economics and Business and Multidisciplinary Sciences. Those areas have an indirect impact on the development of agricultural universities. Agricultural universities can selectively develop the other subjects

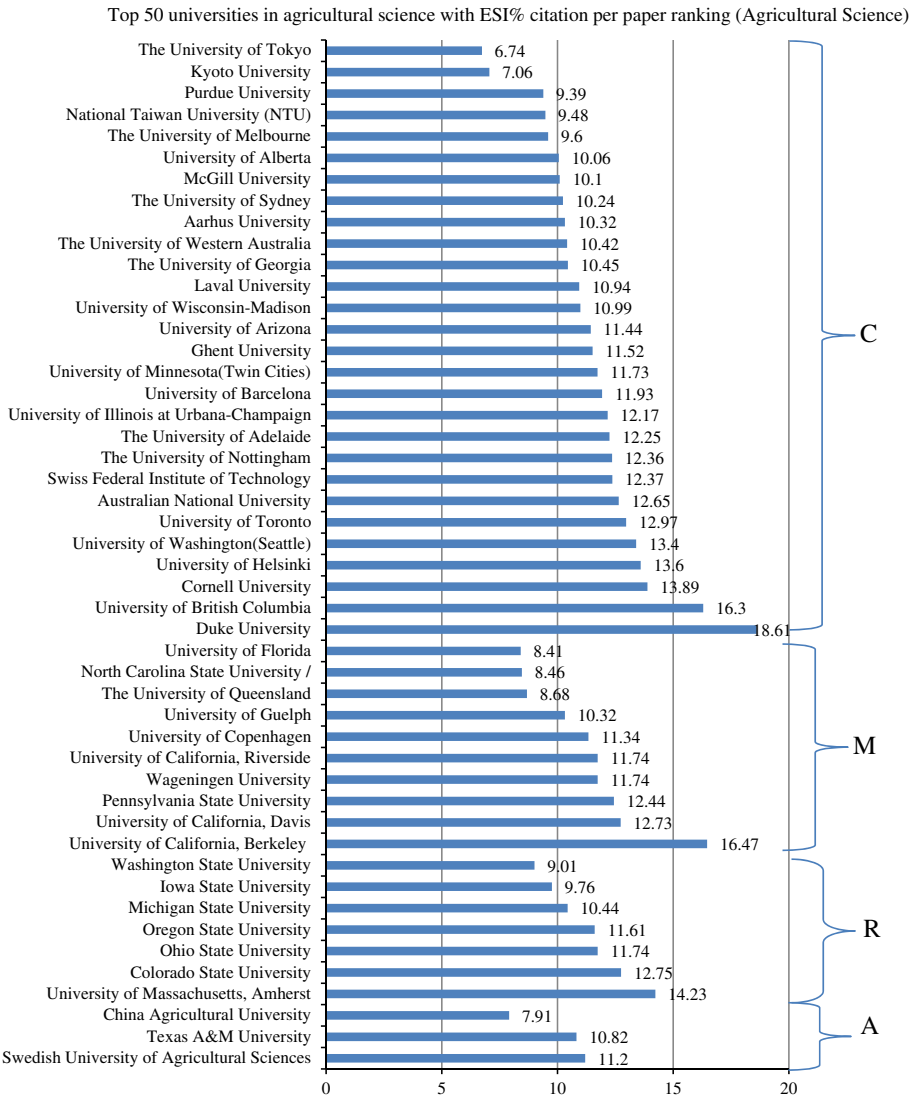
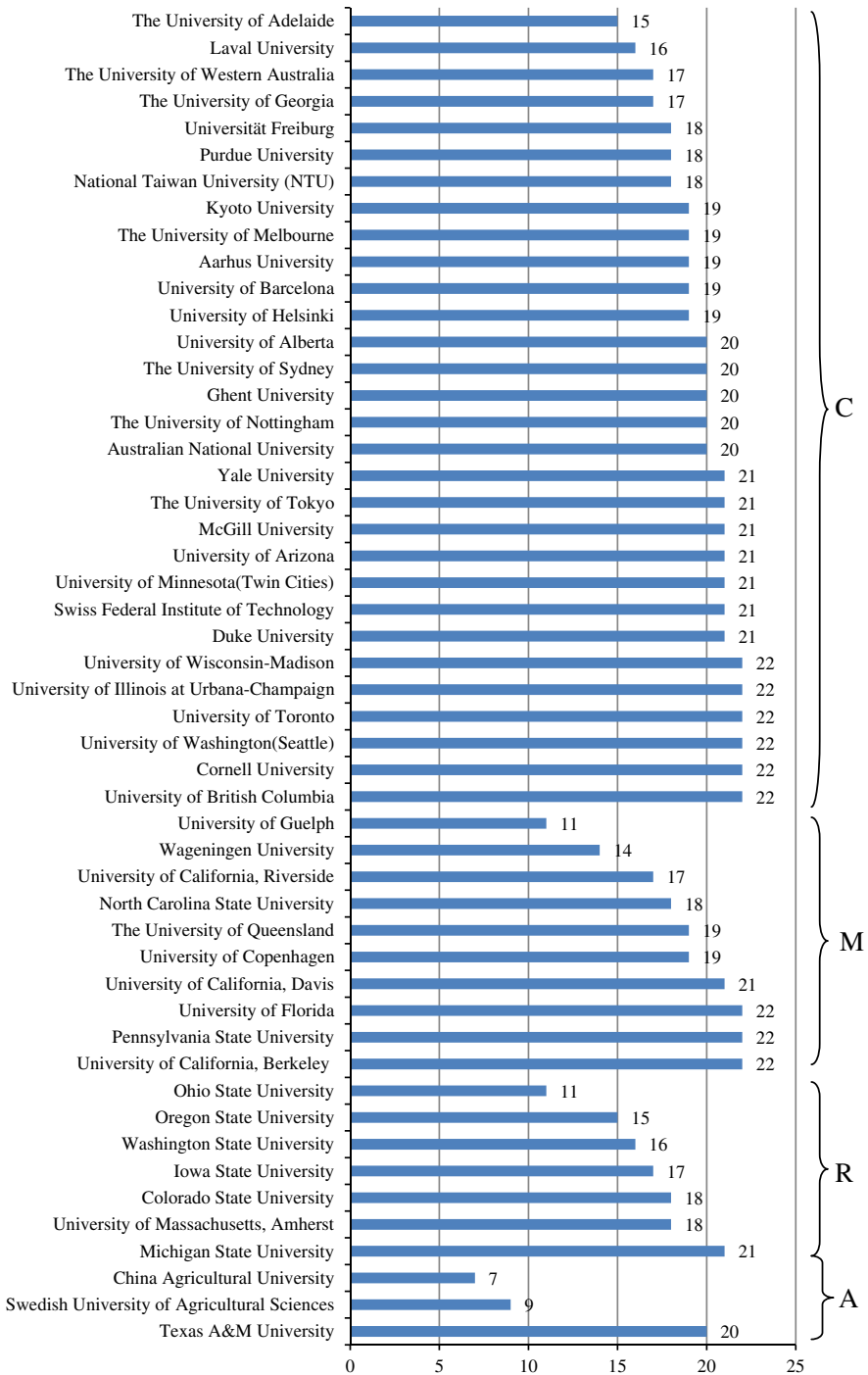


Fig. 2 Top 50 universities in agricultural science with ESI % citation per paper ranking (agricultural science). *Source:* ESI in the Web of Science database retrieved on 24–26 February, 2015, from <http://202.195.243.66:2111/rankdatapage.cgi>. *Note:* Both Yale University and University Freiburg do not have an agricultural subject ranked in ESI’s top 1 % though they offer agriculture-related subjects

(from the Microbiology to Multidisciplinary) according to their circumstances, as shown in Fig. 4.

According to the 30 comprehensive universities in Fig. 5, all of them have the field of Plant and Animal Science, Environment/Ecology, Chemistry, Engineering, Biology and Biochemistry, Pharmacology and Toxicology, Neuroscience and Behavior, Clinical Medicine, Geosciences and Social Sciences/General. Together with the fields of Agricultural Sciences, Immunology, Material Science, Molecular Biology and Genetics, Psychiatry/Psychology, Microbiology and Physics, they all take up 90 % of the total

Top 50 agricultural universities in all fields of ESI 1% ranking (citations per paper)



◀ **Fig. 3** Top 50 universities in agricultural science with ESI % citation per paper ranking in all fields. *Source:* ESI in the Web of Science database retrieved on 23–25 February, 2015, from: <http://202.195.243.66:2111/rankdatapage.cgi>

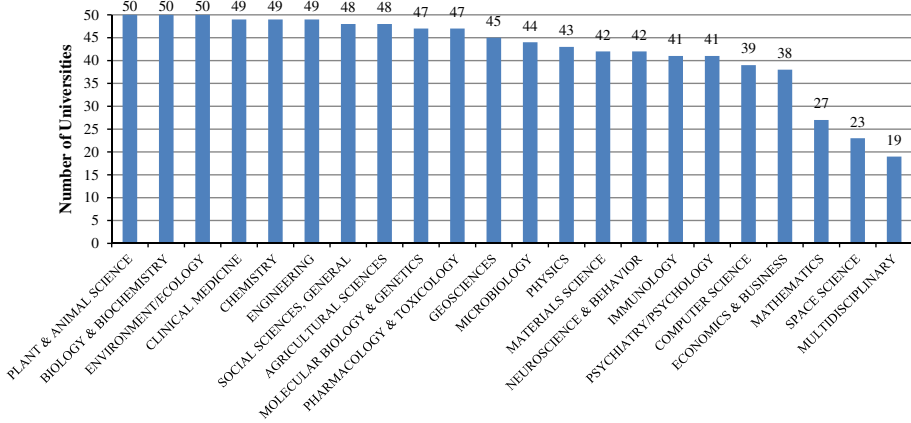


Fig. 4 Programs offered in top 50 universities in agricultural science globally. *Source:* data in Fig. 4 retrieved on 23–25 February, 2015, from <http://202.195.243.66:2111/rankdatapage.cgi>

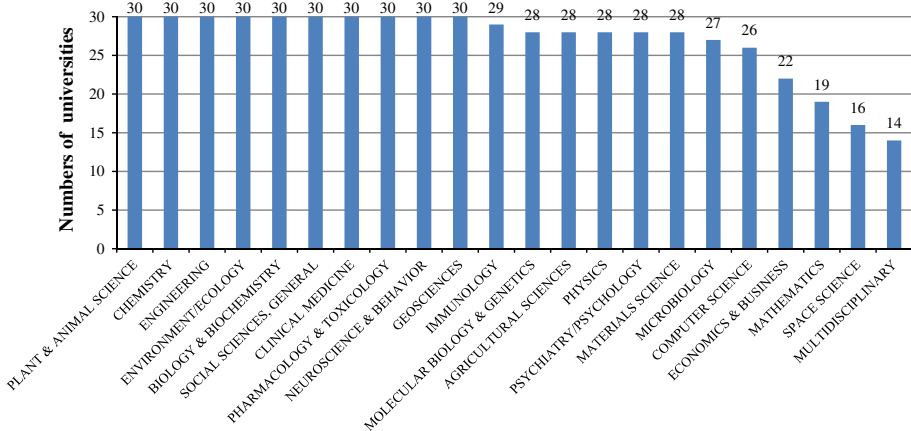


Fig. 5 Academic agricultural programs offered within the above 30 comprehensive universities globally. *Source:* data in Fig. 4 retrieved on 3–25 February, 2015, from <http://202.195.243.66:2111/rankdatapage.cgi>

universities’ subjects. The other two fields (Computer Science and Economics and Business) take up over 75 % of the total. These are the key fields world agricultural universities can pursue. It is easy to understand that these fields have a close link to the agricultural sciences. The least portion of fields is found in Space Science, Mathematics and Multidisciplinary Sciences. As to the other subjects (from the Microbiology to Multidisciplinary), agricultural universities can selectively develop according to their practical situations, as shown in Fig. 5.

In summary, the possible subjects for agricultural universities to develop are listed in the following order: Plant and Animal Science, Biology and Biochemistry, Environmental/Ecology, Clinical Medicine, Chemistry, Engineering, Social Sciences/General, Agricultural Sciences, Molecular Biology and Genetics, Pharmacology and Toxicology and Geosciences. Ranking by subject is a comprehensive guide to a world-class university, as it provides information on the world's top universities on each subject area and its respective specialist strength. Most of the agricultural courses allow students to choose a field of specialization as they progress, while some are already fairly specialized so as to begin with a significant number of agricultural students. The range and combination of subjects taught vary depending on the institution. Agricultural science requires students to have a good grasp of both natural sciences and social sciences. This implies that the strength of subjects is not only concentrated on the top universities, but also the intrinsic mechanism of why comprehensive university has the advantage in any subject formation needs further exploitation.

Conclusions

The paper addresses the following issues: It would be possible for specialized universities to be as world-class levels in their fields by being a major concentration of teaching and research as well as extending other subjects through merging and renaming. This is because the world university ranks normalize their measures by institutional size which is favoring bigger institutions, which not only includes the comprehensive universities, but also specialized ones, while most of the top 50 universities by citations per agriculture paper in Thomson Reuters' Web of Knowledge Essential Science Indicators (ESI) also publish highly cited papers in several other fields and thus are more comprehensive than specialized. More specific conclusions can be drawn as follows:

- 1) If we define the globally acknowledged universities in agricultural science as those which are ranked in all of the three rankings of NTU, QS and ARWU in agricultural subjects, then the top 50 of them are as shown in Tables 1 and 2. Most of these universities are comprehensive, up to 94 % (combination of R, M and C), and only 6 % of them retain a solely agriculture name. Some 48 % of all universities in the sample are from the USA, of which nearly 90 % are land-grant universities. This strongly suggests that government played a crucial role in establishing WCUs in agricultural science in the USA.
- 2) "Double 5 rankings"—being ranked within top 500 of world overall rank and top 50 in agriculture subject rank in any university ranking is a preliminary standard for these so-called WCUs in agricultural science.
- 3) These top 50 universities can be classified into four types by their historical development: A (Agricultural Universities amalgamated with other universities to be an agricultural comprehensive university), R (Agricultural Universities re-named to be a comprehensive university), M (Agricultural Universities merged into other units to form or to be a part of a comprehensive university) and C (Comprehensive university's agricultural colleges or department all the time). The majority of these universities are type C, which takes up to 60 % of the total, and the next ones are type R and type M, both of which together share 34 % of the total. The traditional agricultural universities (type A) are only 6 % of the sample universities, and all of the original agricultural universities have shifted their focus and mission, which leads

to the point of view that merging, renaming and comprehending are the three characteristics of agricultural universities' development trends from the perspective of establishing world-class universities in agricultural science.

- 4) Agricultural universities may be beneficial as they embark on the process of comprehensiveness, but no evidence shows that the most comprehensive a university is, the more academic units it has or, the more comprehensive, the stronger its subjects. The intrinsic mechanism for the benefit of a comprehensive university in advanced subjects' formation needs to be further exploited.
- 5) The benchmarks are: type C, Duke University, the University of British Columbia and Cornell University; type R, University of Massachusetts, Amherst and Colorado State University; type M, University of California, Berkeley and the University of California, Davis; and type A, Swedish University of Agricultural Sciences and Texas A&M University. Some universities, say Wageningen University, have undergone both merging and renaming.
- 6) Several of these top 50 universities have an advantage in the top 1 % ESI of between 6 to 18 subjects in agricultural sciences. For a world-class agricultural university, more than 9 subjects in the ESI top 1 % are necessary. They should focus on the following order of subjects: Plant and Animal Science, Biology and Biochemistry, Environmental/Ecology, Clinical Medicine, Chemistry, Engineering, Social Sciences/General, Agricultural Sciences, Molecular Biology and Genetics, Pharmacology and Toxicology and Geosciences.
- 7) It can be inferred that similar considerations apply in agricultural universities and other universities offering specialized programs, such as universities of forestry, engineering, industry, mining, medicine, politics and law, finance, electric power, communication, transportation, and even in comprehensive universities. The findings obtained from this research should be useful to other kinds of universities.

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