

Role of Animal Agriculture for the Quality of Human Life in the 21st Century* - Review (Keynote Speech) -

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ABSTRACT : The role of animal agriculture for the quality of human life has always been emphasized during 20th century and it is expected to be even more important in terms of food supplies and in providing additional functions in the future. The world human population has almost tripled during a period of half century. The world population of animals has increased 2~3 times (6 times for chicken) during the last 60 years, and the total amount of livestock products has increased 5~6 times (more than 10 times in pork) with higher annual growth rate (9%) in developing countries. Increased personal income certainly encouraged demand for animal products over grains and lower animal production costs resulted from scientific and technological advances. Similarly the production of total grains has more than doubled owing to the advances in agricultural science during the later part of the 20th century. The average life span of world people in 1950s was only 46 years, which will be increased to almost 66 years in the year 2000. Present data clearly indicate that the life span of people is proportional to their income (GNP) and/or animal protein intake. Animals can provide other resources than foods. The increase of human population indicates that the number of animals as well as per capita consumption of animal products will be increased in the 21st century. The other resources we get from animals are drafts, packing, riding, hunting and herding. Guiding the blind, protection and companionship are also examples of what we can expect from animals. In the very near future, animals will become major donors of organs, skins and producers of drugs or special functional foods. It may be concluded that animals are very closely associated and related to the quality of human life, and they are expected to remain the same way in the 21st century. (*Asian-Aus. J. Anim. Sci. 1999, Vol. 12, No. 5 : 815-836*)

Key Words : Animal Agriculture, Per Capita Consumption, 21st Century, Quality of Human Life, Scientific Achievement

INTRODUCTION

The world human population was 2.5 billion in 1950, in 1996 reached 5.7 billion and the estimation of the population for the year 2020 is 7.9 billion. Dramatic increases in the human population result in many problems such as malnutrition and environmental destruction. It is well documented that over 900 million people are suffering from undernourishment partly due to insufficient production and uneven distribution of cereals and crop production. These facts indicate that the availability of foods of animal origin will play a key role in solving the nutritional problems in the world in the future.

Most organizations - scientific societies, universities, and research institutes related to animal agriculture - were established in the 20th century. These organizations contributed to most of the achievements in the field of animal science and livestock production we currently enjoy.

Recent statistics indicate that the growth rate of production and consumption of animal products during the last ten to twenty years has been very low in most developed countries. On the other hand, most developing countries maintain tremendous increases in both production and consumption of animal products.

Even distribution of animal products become more important in terms of food supply to the global population.

The role of animals for quality of human life is expected to be even more important in the 21st century in terms of food supply and other functions.

The purpose of this keynote speech is to review the achievements made in the 20th century in the field of world animal agriculture and their increasing role or contribution to the quality of human life. An attempt will also be made to project the trend in the numbers of animals to be raised, the production and consumption of animal products and other possible roles of animal agriculture for the quality of life in the 21st century.

REVIEW OF ACHIEVEMENTS IN THE 20TH CENTURY

1. Advances in animal agriculture

1) Increase in global population

Human population has increased persistently during the 20th century. As shown in table 1, annual growth of the world population during the earlier period of the 20th century (1930s and 1940s) was a little lower than 2%, and total population remained around 2 billion. From the 1960s the growth rate increased considerably compared to the earlier part of the century (1.52% from 1937 to 1961, increasing to 1.80% from 1961 to

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Table 1. World population (unit : million people)

Item	1937 ¹	1948 ¹	1961	1977	1987	1996	Annual Growth (%)	
							37-61	61-96
Total population	2,150	2,354	3,086	4,227	5,021	5,768	1.52	1.80
Agricultural population	1,333 ²	1,394 ²	1,712	2,140 ³	2,399	2,592	1.05	1.19
Economically active population	-	-	1,371	1,837 ³	2,362	2,768	-	2.03
Economically active agricultural population	-	-	785	957 ³	1,178	1,305	-	1.46

¹ FAO, 1949, 1950; ² Estimated from FAO, 1949; ³ Agricultural Statistics, 1993.

Source : FAOSTAT, 1998

Table 2. World cattle numbers (unit : 1,000 head)

Region	1939 ¹	1961	1987	1997	Annual Growth (%)
Africa	75,000	122,077	175,973	201,228	1.72
North America	102,000	108,396	112,785	113,976	0.19
South America	106,000	144,503	257,520	297,512	1.80
Asia/Oceania	243,000	342,832	418,134	478,210	1.17
Europe	102,000	116,508	127,101	105,840	0.06
Former USSR	63,200 ²	75,780	122,103	80,962	0.42
World Total	628,000³	941,445	1,265,497	1,323,962	1.29

Source : FAOSTAT, 1998; ¹ FAO, 1949; ² 1938; ³ excl. former USSR.

Table 3. World buffalo numbers (unit : 1,000 head)

Region	1939 ¹	1961	1987	1997	Annual Growth (%)
Africa	1,446	1,501	2,454	2,800	1.15
North America	-	-	-	-	-
South America	-	63	1,083	1,701	9.59 ²
Asia/Oceania	74,016	85,940	140,854	147,899	1.20
Europe	654	528	159	142	-2.60
Former USSR	39 ³	389	400	532	4.30
World Total	76,158⁴	88,426	144,959	153,078	1.21

¹ FAO, 1949; ² Annual growth, 1961-1997; ³ 1935; ⁴ excl. former USSR.

Source : FAOSTAT, 1998

1996). Slower advances in nutritional and medical sciences and the two world wars might have influenced global population growth during the first half of the 20th century.

The agricultural portion of the total population decreased from 62% in 1937 to 45% in 1996, while the annual growth of the agricultural population increased by only 0.14% compared to 0.28% in the total population. A similar trend appears in the relationship between the economically active population (2.03%) and the economically active agricultural population (1.46%), the latter being 65% of the former. This trend may be explained by various developments such as urbanization, mechanization and increased efficiency of production.

2) Increase in number of livestock

Table 2 summarizes trends in the world cattle population and annual growth by regions. Cattle

provides agricultural power in addition to animal products, especially in underdeveloped and developing countries. World cattle numbers almost doubled during the 60 years from 1939 to 1997. The cattle raised in Africa, South America and Asia/Oceania in 1939 were 12%, 17% and 39% of the world, respectively. Whereas the proportions changed to 15%, 22% and 36%, respectively by 1997. The biggest change in annual growth of cattle populations occurred in South America with 1.80%, and Africa had 1.72% which is the second largest. The annual growth of the other continents including Asia/Oceania changed little and were less than the world average (1.29%).

Changes in the number of buffalo showed a similar trend to cattle. As shown in table 3, the most significant increase was observed in South America with an annual growth rate of 9.59% from 1961 to 1996, although this population represents only about 1% of world buffalo in 1996. The majority of buffalo

Table 4. World sheep numbers (unit : 1,000 head)

Region	1939 ¹	1961	1987	1997	Annual Growth (%)
Africa	103,000	135,126	193,807	212,065	1.25
North America	61,000	33,482	10,874	8,925	-3.26
South America	97,000	118,441	104,030	87,759	-0.17
Asia/Oceania	256,000	433,243	535,071	545,040	1.31
Europe	119,000	133,718	155,812	136,656	0.24
Former USSR	57,300 ²	133,014	142,210	74,808	0.45
World Total	636,000³	994,072	1,148,980	1,072,567	0.91

Source : FAOSTAT, 1998; ¹ FAO, 1949; ² 1937; ³ excl. former USSR.

Table 5. World goat numbers (unit : 1,000 head)

Region	1939 ¹	1961	1987	1997	Annual Growth (%)
Africa	64,449	94,255	157,101	179,684	1.78
North America	11,792	3,485	1,806	1,678	-3.31
South America	15,488	18,692	20,688	22,632	0.66
Asia/Oceania	115,620	197,797	298,205	456,485	2.40
Europe	23,722	15,184	13,451	15,436	-0.74
Former USSR	9,300 ²	7,290	6,491	6,588	-0.58
World Total	182,371³	347,817	510,788	695,991	2.34

Source : FAOSTAT, 1998; ¹ FAO, 1949; ² 1937; ³ excl. former USSR.

Table 6. World pig numbers (unit : 1,000 head)

Region	1939 ¹	1961	1987	1997	Annual Growth (%)
Africa	3,000	5,668	13,842	22,114	3.50
North America	62,000	60,561	60,918	68,395	0.17
South America	30,000	38,347	51,045	57,803	1.14
Asia/Oceania	87,000	121,498	417,973	558,723	3.26
Europe	78,000	109,441	189,445	167,440	1.33
Former USSR	30,600 ²	58,674	79,501	42,992	0.58
World Total	260,000³	406,109	837,661	938,944	2.24

Source : FAOSTAT, 1998; ¹ FAO, 1949; ² 1938; ³ excl. former USSR.

Table 7. World chicken numbers (unit : 1,000 head)

Region	1939 ¹	1961	1987	1997	Annual Growth (%)
Africa	71,503	274,201	778,808	1,047,302	4.74
North America	547,741	820,962	1,321,644	1,692,000	1.96
South America	117,084	238,804	834,472	1,553,781	4.56
Asia/Oceania	457,265	1,131,173	3,821,021	6,648,101	4.72
Europe	651,350	881,142	1,313,283	1,206,403	1.07
Former USSR	216,000	448,000	1,125,200	655,160	1.93
World Total	2,054,943²	3,900,245	9,555,862	13,384,560	3.28

Source : FAOSTAT, 1998; ¹ FAO, 1949; ² excl. former USSR.

(97%) are kept in Asia/Oceania, where the annual growth rate is only 1.20%.

The numbers of sheep and goats increased tremendously during the same period from 1939 to 1997 as shown in tables 4 and 5. The major sheep

and goat raising area is Asia/Oceania, with Africa being the second in numbers of sheep and goats. In 1997, Asia/Oceania and Africa kept 51% and 20% of world population of sheep and goats, respectively. The annual rate of increase of sheep in both regions are

still higher (1.31% and 1.25%, respectively) compared to other regions. The number of goats also show the same trend. The percentage of goats in Asia/Oceania and Africa was 66% and 26% in 1997 respectively. Goats in Asia/Oceania and Africa together account for about 92% of world population, which is more noticeable compared to sheep. The annual growth of goats in both regions is still high (2.40% and 1.78%, respectively).

Tables 6 (pigs) and 7 (chicken) show that world number of pigs and chicken increased more than 3 times and 6 times, respectively during last 60 years. Asia/Oceania has the largest number of pigs and chicken as is seen from tables 6 and 7. Regional differences in the numbers of pigs and chicken are not so dramatic as the numbers of the sheep and goats. The number of pigs in Asia/Oceania account for about 60% of the world population. The highest annual growth was observed in Africa with about 11% and followed by Asia/Oceania (3.26%). The third highest growth was seen in Europe (1.33%).

However, the highest pig - raising region is known to be Asia/Oceania (60%) with the second being Europe (18%), while the African continent has only 2% of world pig population. A similar trend can be found in poultry data, with the highest annual growth in Africa. However, the number of chicken is highest in the Asia/Oceania (50% of the world) and Africa

has the smallest number (8%). South America also has a very high rate of increase in the number of chicken.

3) Increase in production of livestock products

Compared to developed countries, underdeveloped or developing countries have a higher annual growth of livestock products, which is more so in those products from smaller animals. The total amount of livestock products produced in the world during recent decades has increased as shown in table 8, which is probably the result both of increased demand due to the larger human population and of higher consumption per capita by higher income groups. The rate of increase in the production of livestock products in developed countries is constant but lower when compared to that of developing countries. The annual growth of pork production in developing countries was 8.5%. The annual growth of production of all animal products exceeded that of human population during the second half of the 20th century.

4) Improvement in production efficiency

Performances of most major livestock species have improved throughout this century, which is described in the next a few tables. These performance data from selected experiments with beef cattle, dairy cows, pigs, broilers and laying hens mostly in the USA over the latest several decades indicate a continuous improvement

Table 8. World production of livestock products (unit : 1,000 MT)

Item	1946 ¹	1961	1977	1987	1997	Annual Growth (%)
World						
Beef and veal	11,902	27,674	46,361	50,964	55,013	3.05
Mutton and lamb ²	2,440	6,035	6,883	8,623	11,133	3.02
Pork	7,900	24,747	42,866	63,526	88,618	4.85
Chicken meat	-	7,555	18,674	31,453	49,718	5.37 ³
Egg	-	15,183	24,833	34,619	51,389	3.44 ³
Milk	150,360	344,201	446,122	521,660	543,758	2.55
Fishery	-	39,605	67,908	94,669	108,753	2.85 ³
Developed countries						
Beef and veal	8,761	19,189	33,306	34,685	30,719	2.49
Mutton and lamb ²	1,519	3,522	3,372	3,812	3,447	1.62
Pork	7,087	20,373	30,195	37,177	35,207	3.19
Chicken meat	-	5,731	13,424	20,047	24,626	4.13 ³
Egg	-	11,383	16,909	19,314	17,726	1.24 ³
Milk	131,446	276,830	343,836	377,697	340,906	1.89
Fishery	-	22,604	38,198	45,382	32,627	1.02 ³
Developing countries						
Beef and veal	3,141	8,485	13,055	16,279	24,294	4.09
Mutton and lamb ²	921	2,514	3,511	4,811	7,686	4.25
Pork	813	4,375	12,670	26,349	53,411	8.55
Chicken meat	-	1,824	5,250	11,406	25,092	7.55 ³
Egg	-	3,799	7,923	15,306	33,663	6.25 ³
Milk	18,914	67,371	102,285	143,964	202,852	4.76
Fishery	-	17,001	29,464	49,249	75,990	4.25 ³

¹ FAO, 1949; ² Mutton, lamb and goat meat; ³ Annual growth, 1961-1997.

in production efficiency. In table 9, improvement in performances of beef cattle during the last half century is depicted.

Average daily gain of beef cattle in the 1940s was 604 g/day and was improved to 1,348 g/day in the 1990s, which is a 123% increase. Feed efficiency was improved by 70% during the same period. Advances in feeding and management technology together with genetic improvement possibly resulted in these improvements in beef cattle performance. A notable improvement in the lactating performance of dairy cows was also achieved during this century as shown in table 10. Average milk production was increased from 3,466 kg/year in the 1920s to 11,844 kg/year in the 1990s, which is an improvement of 242% (table 10).

Table 9. Improvement in growth performance of beef cattle

Year	ADG ¹ (kg)	Gain/ Feed	Weight (kg)	References
1940s	0.604	0.080	201.8-489.9	Connet et al., 1948
1950s	0.917	0.095	211.6-326.9	Beenson et al., 1958
1960s	1.048	0.107	253-473	Perry et al., 1967
1970s	1.140	0.127	370-470	Ullrey et al., 1977
1980s	1.340	0.130	360-496	Hsu et al., 1987
1990s	1.348	0.136	335-513	Milton et al., 1997

¹ ADG : Average daily gain.

Table 10. Improvement in milk production of dairy cows

Year	Milk Production (kg/year)	References	Remarks
1920s	3,466	Colle et al., 1980	DHIA cow ¹
1930s	3,689	"	"
1940s	4,160	"	"
1950s	4,790	"	"
1960s	5,783	"	"
1970s	7,015	Smith et al., 1977	-
1980s	8,260	Bauman et al., 1989	-
1990s	11,844	Vazquez-anon et al., in late lactation 1997	period

¹ Annual milk production of cows on dairy herd improvement Association Program.

Table 11 shows the improvement in growth performance of pigs. Average daily gain of pigs in the 1940s was 580 g/day, which increased to 870 g/day in the 1990s. Feed efficiency was also increased from 0.28 to 0.37 during these periods. Improvement in daily gain and feed efficiency during 50 years were 50% and 32%, respectively.

Table 11. Improvement in growth performance of pigs

Year	ADG ¹ (g)	Gain/ Feed	Weight (kg)	References
1940s	580	0.28	20.6-85.9	Sidney et al., 1946
1950s	670	0.28	23.8-86.1	Sewell et al., 1957
1960s	700	0.29	26-82	Hutagalung., 1968
1970s	730	0.31	22-90	Seerley et al., 1978
1980s	779	0.34	29-99	Lindemann et al., 1986
1990s	870	0.37	20-100	Tuitoek et al., 1997

¹ ADG : Average daily gain.

Broiler chicks in the 1990s gained 24.8 g/day more than chicks in the 1930s and the feed efficiency was improved from 0.184 in the 1930s to 0.719 in the 1990s, which is a 291% improvement (table 12). Laying hens in the 1990s produced almost two times more eggs compared to those in the 1920s. The egg production rate in the 1920s was 41.4% which was improved to be 92.5% in the 1990s (table 13).

Table 12. Improvement in growth performance of broilers

Year	ADG (g)	Gain/ Feed	Period	References
1930s	6.34	0.184	0-4 wks	Mayward et al., 1937
1940s	11.22	0.296	0-4 wks	Parkhurst et al., 1944
1950s	12.21	0.470	0-4 wks	Baldwin et al., 1957
1960s	12.68	0.460	0-4 wks	Carew et al., 1967
1970s	24.33	0.541	0-3 wks	White et al., 1977
1980s	26.03	0.714	0-3 wks	Ruiz et al., 1987
1990s	31.14	0.719	0-3 wks	Newkirk et al., 1997

¹ ADG : Average daily gain.

Table 13. Improvement in egg production of laying hens

Year	Egg Production ¹ (%, Hen- day basis)	Laying Hen Type	Reference
1920s	41.4	White Leghorn	Hannas, 1922
	49.9	Leghorn	Waters, 1927
1930s	50.2	"	Platt, 1936
1940s	64.9	Leghorn+	Cravens et al., 1946
		Plymouth	
1950s	64.3	Leghorn	Thornton et al., 1957
1960s	69.8	"	Harms et al., 1967
1970s	72.8	"	Lillie et al., 1976
1980s	78.2	"	Goodling et al., 1987
1990s	92.5	"	Van der Klis et al., 1997

¹ Annual average production.

Table 14. Per capita consumption of animal products (unit : kg/capita/year)

Item	1946 ¹	1961	1977	1987	1995	Annual Growth (%)
World						
Beef	5.15	9.23	11.22	10.45	9.71	1.30
Pork	3.42	7.96	9.99	12.48	14.59	3.00
Chicken meat	-	2.86	4.96	7.06	9.45	3.58 ²
Egg	-	4.56	5.33	6.17	7.29	1.39 ²
Milk	65.12	74.74	74.90	77.72	76.25	0.32
Fishery	-	9.01	11.43	13.28	13.24	1.14 ²
Developed countries						
Beef	13.91	19.88	29.45	27.69	23.67	1.09
Pork	11.25	20.50	25.76	29.60	27.88	1.87
Chicken meat	-	6.73	12.87	18.30	20.67	3.36 ²
Egg	-	10.75	13.42	14.24	12.14	0.36 ²
Milk	208.64	174.38	190.26	201.58	194.99	-0.14
Fishery	-	17.30	22.94	27.01	22.66	0.80 ²
Developing countries						
Beef	1.87	4.24	4.42	4.83	5.61	2.27
Pork	0.48	2.09	4.10	6.90	10.67	6.53
Chicken meat	-	1.04	2.00	3.40	6.16	5.37 ²
Egg	-	1.65	2.31	3.54	5.87	3.80 ²
Milk	11.27	28.05	31.82	37.35	41.30	2.69
Fishery	-	5.13	7.13	8.81	10.46	2.12 ²

Source : FAOSTAT, 1998; ¹ FAO, 1949; ² Annual growth, 1961-1995.

Table 15. Present production and per capita consumption of meats

Item	Meat Production (1,000 MT, 1997)	Consumption (kg/capita/year, 1995)
World	220,023 (100%)	36.29(100%)
Beef	55,013 (25.0)	9.71 (26.8)
Mutton ¹	11,133 (5.0)	1.81 (5.0)
Pork	88,618 (40.3)	14.59 (40.2)
Chicken meat	49,718 (22.6)	9.45 (26.0)
Other meat	15,542 (7.1)	0.72 (2.0)
Developed countries	100,496 (100%)	76.06(100%)
Beef	30,719 (30.6)	23.67 (31.1)
Mutton ¹	3,447 (3.4)	2.44 (3.2)
Pork	35,207 (35.0)	27.88 (36.7)
Chicken meat	24,626 (24.5)	20.67 (27.2)
Other meat	6,497 (6.5)	1.40 (1.8)
Developing countries	119,528 (100%)	24.59(100%)
Beef	24,294 (20.3)	5.61 (22.8)
Mutton ¹	7,686 (6.4)	1.63 (6.6)
Pork	53,411 (44.7)	10.67 (43.4)
Chicken meat	25,092 (21.0)	6.16 (25.1)
Other meat	9,045 (10.5)	0.52 (2.1)

Source : FAOSTAT, 1998; ¹ Mutton, lamb and goat meat.

throughout the 20th century. People in most parts of the world used to consume less animal products than cereals or grains because of the comparative abundance during the earlier part of the 20th century. As the number of the livestock increased, people tended to consume more livestock products. Increased income allowed people to choose animal products over grains, and lower production cost thanks to scientific and technological advances also contributed to increase in the availability of animal products at cheaper prices. Tables 14 and 15 show the trend of per capita consumption of animal products.

The consumption of all livestock products increased as years go by in developing countries. In developed countries consumption per capita of all animal products, except chicken, reached a peak in the 1980's, and then slightly decreased since then. It is interesting to note that increasing rate of per capita consumption of animal products including milk and fish of developing countries is much higher than developed countries. As shown in the table 14, annual growth of chicken meat consumption in the developed countries during the last 50 years reached 3.36%, which is the highest increase of all products. Meanwhile, annual growth of the same chicken meat consumption in developing countries was 5.37%. The most remarkable change can be seen in the pork consumption in developing countries. The annual growth of pork consumption in developed countries

5) Per capita consumption of foods of animal origin
Food consumption patterns have been changing

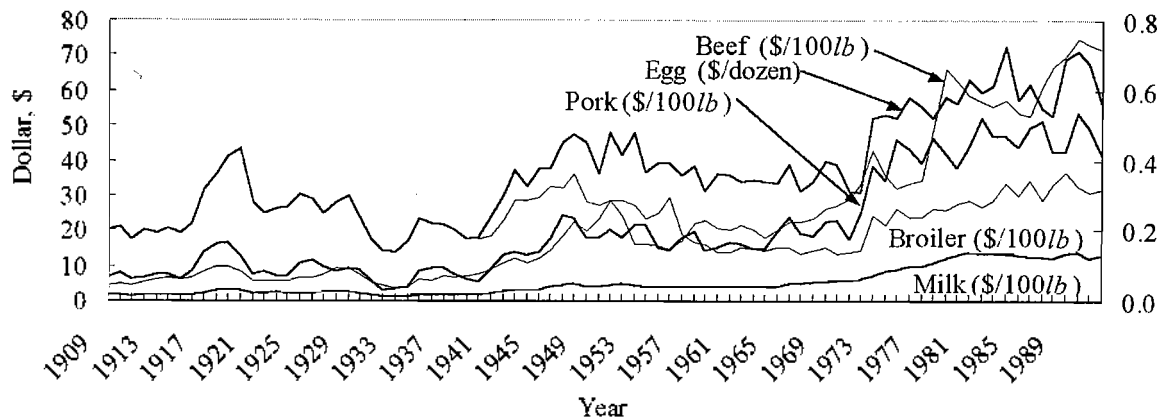


Figure 1. Trends in international consumer prices of animal products (Source : FAOSTAT, 1998; * Egg prices are adopted on right Y axis)

Table 16. World production of total cereals (unit : 1,000 MT)

Region	1961	1977	1987	1997	Annual Growth (%)
Africa	46,172	65,864	83,216	112,958	2.52
North America	180,531	308,449	332,068	389,772	2.16
South America	36,175	63,924	82,614	101,252	2.90
Asia/Oceania	339,079	588,300	783,818	995,546	3.04
Europe	144,933	230,982	275,281	296,758	2.01
Former USSR	118,776	175,422	185,021	144,102	0.54
World Total	876,890	1,455,212	1,771,024	2,074,790	2.42

Source : FAOSTAT, 1998.

Table 17. World production of coarse grains (unit : 1,000 MT)

Region	1961	1977	1987	1997	Annual Growth (%)
Africa	36,764	50,373	60,340	81,828	2.25
North America	136,821	228,419	242,882	289,848	2.11
South America	20,940	41,667	48,515	63,299	3.12
Asia/Oceania	87,407	132,429	167,740	207,877	2.44
Europe	92,129	146,984	156,644	163,665	1.61
Former USSR	56,052	86,694	105,262	65,475	0.43
World Total	438,933	704,349	803,604	900,564	2.02

Source : FAOSTAT, 1998.

was 1.87% during the last half of the 20th century, but in developing countries, it averaged up to 6.53%. Of course, the actual amounts consumed in developed countries are much higher than developing countries in all items. But the demand rate of increase of developing countries exceeded that of developed countries.

6) Changes in consumer price of animal products

Figure 1 shows the changes in international consumer prices for animal products during the 20th century. Considering the general increase in consumer

prices of other commodities during this period, the price increase of animal products has been very low. Prices of all the animal products have been increased gradually, which means that animal products have been available at relatively cheap prices, and a similar contribution is expected from the animal industry in the future.

7) Production of cereals

In general, the production of total cereals in all continents has doubled owing to the advances of agricultural sciences during the last half of the 20th

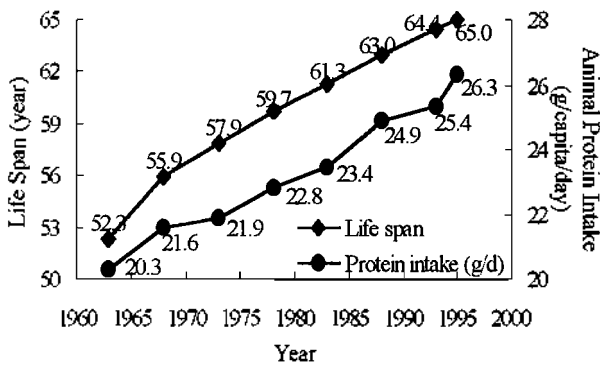


Figure 2. Changes in world life span and animal protein intake (Source : FAOSTAT, 1998)

century (table 16). In 1997 Asia produced 47% of total cereals in the world with annual growth rate of 3.04% from 1961 to 1997. The second largest regional producer of the total cereals is North America with 21% of the world production and 2.16% of annual growth. Table 17 shows that the production of coarse grains tended to follow the trend of total cereals. However, the largest regional producer of coarse grains is North America (36%) with 2.11% annual growth, and followed by Asia (24%) with 2.44% of annual growth. South America is the region with the highest annual growth in coarse grain production (3.12%), but the total amount produced was not very large compared to other regions of the world.

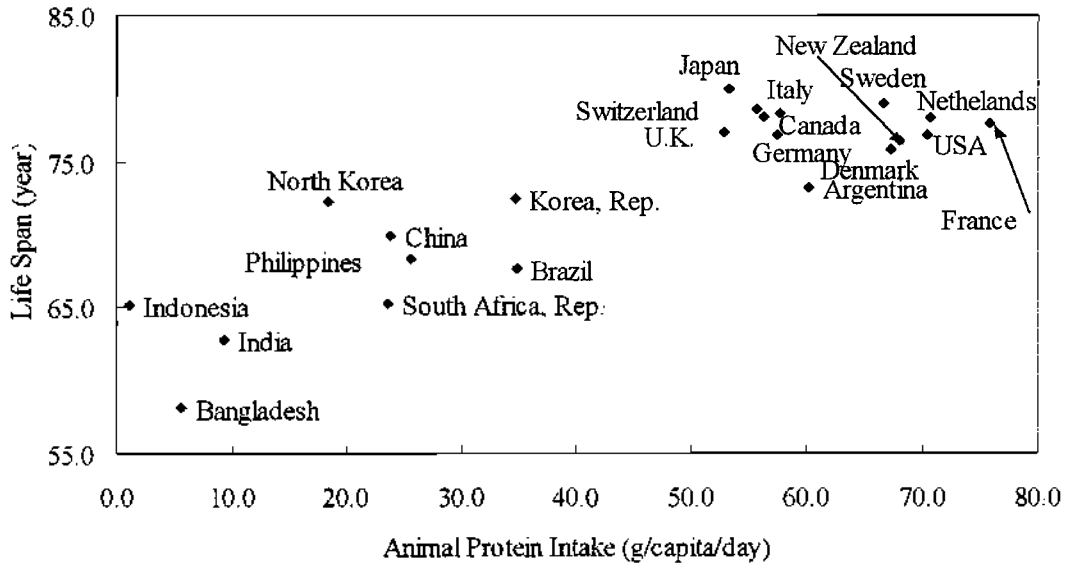


Figure 3. Relationship between animal protein intake and life span in selected countries

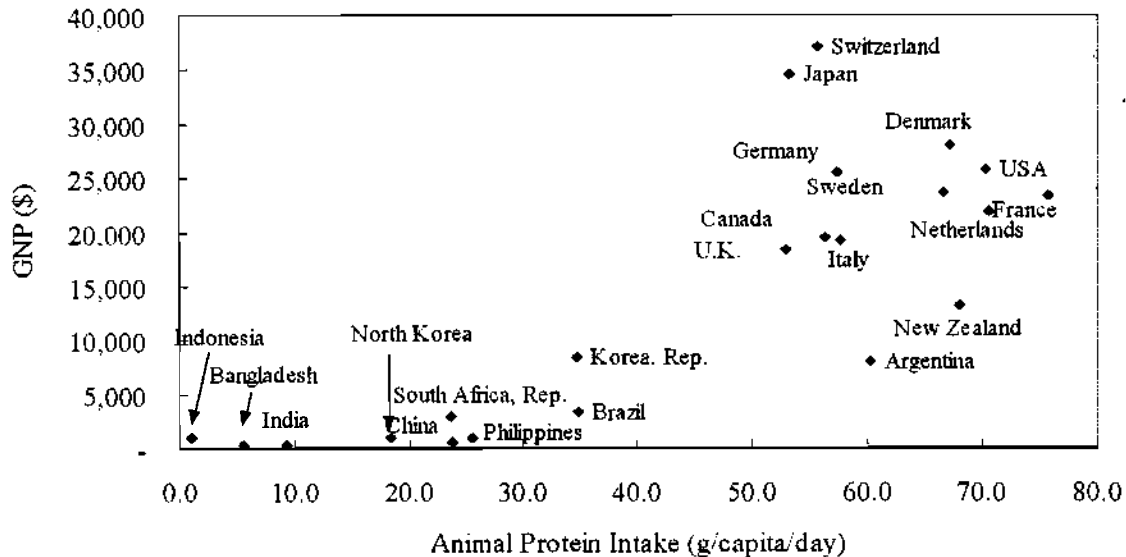


Figure 4. Relationship between animal protein intake and GNP in selected countries

2. Animal agriculture and the quality of human life

1) Increase in average life span of human

The life span of people has increased steadily throughout the 20th century (figure 2). The average life span in the world in 1950s was only 46.4 years, which increased to almost 65 years by 1995, meaning that people live for almost 20 years longer. Factors affecting life span are variable, but certainly food availability is one of the keys. Figures 3 and 4 well illustrate the relationship between animal protein intake or GNP and life span. GNP and life span are two primary concerns related to human welfare. Nowadays some consider that higher consumption of animal products has negative effects on human health because of the amount and type of fat delivered by animal foods. However, protein provided through animal products is one of the most important contributors to well-balanced nutrition, leading to a healthier and prolonged life span. As seen in figures 3 and 4, people in most developed countries tend to consume more protein of animal origin and live longer than people in developing areas. On the other hand, animal protein supply in most developing countries is not sufficient enough to support daily requirement.

2) Diversification of animal uses

Animals can provide various other functions in addition to food. People domesticated animals long ago (table 18) and used them as "tools" for human life. Animals have been used as a source of physical power for transportation and cultivation (table 19).

Table 18. Domestication history of animals

Animal	Domesticated Area	Estimated Time (year)	References
Cattle	South-Central Asia, Minor (Anatolia)	7,800	Mellaart, 1967
Pig	South Western Asia Northern China	8,500 6,000	Reed, 1977
Sheep	Zawi, Northern Iraq	10,700	Perkins, 1964
Horse	Conflict theory, insufficient evidence		
Water Buffalo	Northern India	BC 2,500	Zeuner, 1963; Epstein, 1971
Reindeer	Northern Eurasia	BC 14,000 (?)	Herre, 1955; Zeuner, 1963
Rabbit	Southwestern Europe	early	Zeuner, 1963
Dog	Norther Iraq South Western Asia	medieval 14,000-12,000	Valla, 1977

Source : Cole and Garrett, 1980.

Table 19. Animal use except product

Purpose	Animal (in approximate order of importance)
Draft	Horse, Ox (<i>Bos Taurus</i> & <i>Bos Indicus</i>), Buffalo (<i>Bubalus bubalis</i>), Mule, Donkey, Reindeer, Moose Camel, Dog
Packing	Horse, Mule, Donkey, Water Buffalo, Ox, Yak
Herding	Dog
Guiding the blind	Dog
Protection	Dog, Cat (to protect against rodents)
Hunting	Dog

Source : Cole and Garrett, 1980.

Dogs have been utilized for herding, hunting, guiding or as a companion animal throughout the history of human civilization. Animals also give a means of sport, recreation and as companion animals, which is likely to become one of more important roles of animals after supplying foods. Certainly animals are very closely associated and related to human life, and they are expected to remain the same way in the coming century.

3) Recent advances in animal sciences

In this section, technological advances established in animal sciences in the 20th century are briefly reviewed.

(1) Gene mapping & animal genetic resources:

For a long time the performance of animals was improved by conventional genetic methods such as selection and culling. As everyone knows, the process is slow with low probability. Thanks to the development of new technology in the later part of the 20th century, selecting animals with desired traits become with quantitative genetics. More recently advanced technology in molecular biology and gene mapping make it possible for us to have better understanding of genes for given purposes, especially for the purpose of animal breeding. It is probable that within a short period of time we shall see new breeds with various special functions.

Genetic maps for livestock species are being developed rapidly, greatly aided by the development of detailed maps of the human mouse genomes. Good maps can help to decide where to look for interesting genetic variation in wild or feral species. Like other new technology the genetic technology can also be used as a good tool for preserving and developing the animal genetic resources. But we have to consider that the conventional breeding methods will continue to be

very useful for a long time. It is true that changes are rather slow, but they are cumulative.

(2) Application of biotechnology:

Biotechnology is the engineering technique able to shape animals with desired traits using advanced methods such as gene manipulation, gene transfer, cell fusion, embryo transfer, IVF, and cell culture. Biotechnology actually is not new because alcoholic fermentation of sugar containing fruits has been recognized long before modern science developed. In the middle of the 19th century, scientists recognized the importance of microorganisms. Today biotechnology is applied to various fields of sciences. For example, it is commonly used in medical sciences (disease prevention, production of preventive medicine, genetic disease treatment), agricultural sciences (creation of new plants and animals), food and specific chemicals (production of flavors and pigments), environmental sciences (waste treatment and natural resources recovery), energetics (pollution-free energy), electronics (biochips). All these kinds of usage could be adopted in agriculture, especially in animal sciences. With these applications, a whole series of different horizons in animal sciences lie before mankind, in the coming 21st century.

(3) Use of metabolic active substances:

Throughout history researchers and producers have been trying to find methods to improve the growth of the animals. Although most nutrients were identified over several centuries, their essentiality and their metabolic functions were elucidated in this century. Before metabolic active substances (antibiotics, probiotics, enzymes, yeasts, hormones, β -agonists, chromium products, etc.) were developed, most of the researchers and producers tried to obtain the optimum growth of the animals through the supply of proper level of nutrients. The advent of a series of metabolic active substances made it possible for animal to grow beyond the limits obtainable with normal nutritional means. Most of these substances are known to enhance animal performance by metabolic modification. They help animals get better digestibility for better performance, and overcome some disease and nutritional disorders. Metabolic disorders can be prevented or cured by antibiotics or probiotics which reduce or suppress undesired microorganisms. It is well known that animal growth and body composition can be altered by the action of exogenous hormones. Dietary enzymes can also improve the digestibility of specific nutrients and, in many instances, of feed, too. Also some of recent research data indicate that the β -adrenergic agonist and chromium products (chromium picolinate, chromium nicotinate, chromium yeast) promote lean accretion in the body. With these

beneficial actions, farmers can produce animal products more effectively and economically with less chance of disease outbreak or potentially restricted growth. Concern about possible side effects from long-term usage of low dosage antibiotics have been raised and some measures has been already imposed throughout the world. Continuing investigations for new, safer and more efficient metabolic agents are expected in the coming century.

(4) Use of synthetic amino acids for sparing effect of dietary protein and reduction in pollution:

Advances in fermentation and related technology have paved the way for animal scientists to use a few synthetic amino acids in fortifying animal feeds and to look at their possible roles. From the 1950s, studies on amino acids have been conducted, focusing on lean growth of animal. Amino acids have an important role in animal metabolism for the optimum performance, especially in lean growth, because animal protein is primarily composed of the peptide bonds of amino acids. Furthermore, in the field of animal nutrition and feedstuffs, scientists have proved that the addition of synthetic amino acids result in protein sparing effect. L-lysine is the amino acid most commonly added to animal feeds and other amino acids such as DL-methionine, and L-threonine are also used as supplements to various animal feeds. The relationships between amino acids and lean growth have been an active research area for the last couple of decades. Recently, researchers have begun to look at the possible role of amino acids in the immune system. For example, healthy young animals need less methionine and threonine for their optimum growth, because quite some parts of those amino acids are needed for maintenance, and they are the elements of the immuno protein themselves. Therefore, more research with amino acids is expected on their roles in the nutritional, metabolic and physiological fields in the 21st century.

(5) Processing technology and quality of animal products:

A variety of processing methods have been developed during this century, and now people enjoy various processed animal products on their table, compared to the last century when the only animal products were on a raw state. Processing technology has improved the quality of animal products considerably. Animal products supply nutrients, but often they do not contain sufficient amounts of all nutrients for a balanced human diet, sometimes they are not easily digestible, or suffer from preservation problems. Processing technology plays a role in solving these problems and advances in animal and human nutrition provide humans healthier life now

than the last century.

(6) *Recycling and treatment of animal waste:*

In the early period of animal husbandry, animal residue were regarded as "waste". After cultivating started, people realized that animal waste contains many nutrients necessary for plant growth, and it is used as a natural fertilizer until now. Although during later half of this century many chemical fertilizers have been developed, animal waste is still used as a fertilizer, because it is environmently friendly and has different characteristics from chemical fertilizers. Recently, various efforts are being made to remove the noxious odors from animal waste, which will make the animal waste thus be more easily accepted not only in rural but also in peri-urban areas and thus be used more widely all over the world. Use of animal waste as a fuel source, as practiced in some developing countries, has potential interests in other countries.

(7) *Animal welfare:*

Animal welfare is an issue raised in the later part of this century. Animals are commonly used in experiments, and very often are treated contrary to their comfort. Animals have rights to a comfortable

life. Although we recognize this, it is sometimes necessary to cause animals discomfort or to sacrifice them during or at the end of experiments. For example, many drugs and chemical agents for curing disease are tested using animals before being cleared for humans. Animals contribute valuable information in many scientific fields. Imprudent victimization and excessive maltreatment must be restricted. Although animals serve human welfare, we are convinced that their last right for tranquil and comfortable death must be kept. It must be remembered that they have been sacrificed for human welfare.

4) *Founding of academic societies & publication of scientific journals*

Most academic societies and scientific journals we now have were founded in the 20th century (table 20) with just a few having been started in the earlier century. All those societies and their official journals have played the most important roles in the advancement of animal sciences and livestock industry of the world. All scientific associations publish a journal as a part of their regular activities, and total volumes and pages of selected journals are shown in table 21. In most cases, the number of pages

Table 20. Some academic societies and scientific journals in the field of animal sciences

Societies	Founded	Journals	Founded
· American Society of Animal Science (ASAS)	1908	· J. of Animal Science	1942
· Asian-Australasian Association of Animal Production (AAAP)	1980	· Asian-Australasian J. of Animal Science	1988
· European Association for Animal Production (EAAP)	1949	· Livestock Production Science	1974
· Canadian Society of Animal Science (CSAS)	1921	· Canadian J. of Animal Science	1921
· Chinese Association of Animal Science & Veterinary Medicine (CAASVM)	1936	· Animal Husbandry & Veterinary Medicine, China	1969
· Japanese Society of Zootechnical Science (JSZS)	1924	· Animal Science & Technology	1924
· Korean Society of Animal Science (KSAS)	1956	· Korean J. of Animal Science	1958
· Latin American Association of Animal Production (ALPA)	1981	· Archivos Latinoamericanos de Produccion Animal	1993
· South African Society of Animal Science (SASAS)	1961	· South African J. of Animal Science	1971

Table 21. Publication of selected primary journals

Name of journals	Created year	Pages of Vol. 1	Average pages /year	Total pages	Volume
· Animal Science and Technology (Japan)	1924	337	588	39,984	68
· Livestock Production Science (EAAP)	1974	454	1,411	19,760	51
· Korean J. of Animal Science	1958	56	464	18,548	39
· Asian-Australasian J. of Animal Science	1988	246	575	5,746	10
· Archivos Latinoamericanos de Animal Produccion	1993	210	198	791	4
· Journal of Animal Science	1942	368	2,188	122,555	75
· Journal of Dairy Science	1917	532	1,632	132,213	80
· Poultry Science	1921	219	1,390	107,015	76

Table 22. Some selected universities and research institutes

Name of University or Institute	Founded	Events
Universities		
• Univ. of California, Davis	1905	• Animal Science department was established in 1967.
• Univ. of Illinois	1873	• The Department of Dairy Husbandry formed in 1902.
• Cornell University	1868	• Department of Animal Husbandry was established in 1903.
• Univ. of Wisconsin	1874	• The Department of Agriculture was formed in 1912.
• Univ. of New England, Australia	1938	• Department of Animal Science was formed in 1969.
• Wagenigen Agricultural Univ., The Netherlands	1876	• It is the only agricultural university in Netherlands.
• Aberdeen Univ., UK	1495	• The Agricultural Department was founded in 1895.
• Univ. of Alberta, Canada	1906	• The Department of Agricultural, Food and Nutritional Science was formed in 1994.
• Seoul National Univ., Korea	1904	• It was began as School of Agriculture, Commerce and Technique. Department of Animal Science & Veterinary Medicine was originated in 1937.
• Kyoto Univ., Japan	1897	• It was founded in 1897.
Institutes		
• Rowett Research Institute, UK	1913	• Research areas are in human & animal nutrition and biological sciences of relevance to health, food and agriculture.
• Danish Meat Research Institute, Denmark	1954	• They worked to promote the competitiveness of beef industries through technical research and development activities.
• American Meat Institute, USA	1906	• They provides information on meat production issues to consumers and the media.
• Agricultural Research Center, Germany	1947	• The institute worked on animal and plant health, animal nutrition, grassland and forage research.
• Animal Genetics & Breeding Unit, Australia	1976	• Univ. of New England and the New South Wales State. Department of Agriculture combined to establish the Animal Genetics and Breeding Unit.
• National Livestock Research Institute RDA, Korea	1906	• Animal genetics, nutrition, physiology, waste treatment, grassland & forage, investigation of new feedstuff are main research areas.

Table 23. Foundation and its activities of some international organizations

Name of organization	Founded	Events
• FAO (Food & Agriculture Organization)	1945	• Alleviation of poverty and hunger by promoting agricultural development, improved nutrition and the pursuit of food security.
• WHO (World Health Organization)	1948	• Seeking to attain the highest possible level of health of all people.
• OECD (Organization for Economic Cooperation and Development)	1960	• Contributing to improve world economy through the highest possible level of economy, employment and human welfare.
• UNICEF (United Nations Children's Fund)	1946	• Assisting children's welfare and to attribute the medical and social assistance for developing countries.
• UNDP (United Nations Development Programme)	1965	• Provision of technical assistance to stimulate the economic and social development of developing countries.
• UNFPA (United Nations Fund 052 Population Activities)	1967	• Assistance to governments and research institutes for their activities on human population and planning parenthood.
• ESCAP (United Nations Economic and Social Commission for Asia and the Pacific)	1947	• Helping to rebuild and develop the economy of Asian-Pacific countries. It collects and serves economic and technical informations and statistical data.

Table 24. Summary of the past world conference on animal production (1963 - 1998)

Venue	Period	Name of WAAP president	Name of OC chairman WCAP	No. of papers presented (a)+(b)	No. of participants	No. of countries represented
1. Rome, Italy	Sep. 2-7, 1963	W. R. Trehane	W. R. Trehane	66+200	366	54
2. Maryland, USA	July 14-20, 1968	R. E. Hodgson	R. E. Hodgson	33+186	600	60
3. Melbourne, Australia	May 22-30, 1973	R. H. Watson	R. H. Watson	86+120	600	54
4. Buenos Aires, Argentina	Aug. 20-26, 1978	F. Torres	M. A. A. Morales	34+106	800	52
5. Tokyo, Japan	Aug. 14-19, 1983	Y. Nishikawa	K. Mimura	600	1,229	61
6. Helsinki, Finland	June 27-July 1, 1988	E. Cunningham	E. Poutiainen	450	1,000	70
7. Edmonton, Canada	June 28-July 2, 1993	R. Blair	R. J. Hudson	446	625	72
8. Seoul, Korea	June 28-July 4, 1998	In K. Han	J. K. Ha	210+988	2,159	91

(a) Invited papers. (b) Contributed papers.

published annually was dramatically increased. Once being founded associations also hold annual meetings, which include symposium, presentations and exhibitions.

5) Founding of universities and research institutes

Table 22 presents information on the history of some of selected universities and institutes in the field of animal sciences. Most of the universities have a rather long history and some of them were founded in the 19th century. However, most of them were first founded as a school or college and in the early 20th century they were approved or became universities. Most of the departments of animal sciences were formed in the 20th century. Also the majority of leading research institutes were founded in the 20th century, whether belonging to a university or not. This means that research and education greatly intensified during the 20th century.

6) Founding of international organizations

Various international organizations were founded in the 20th century to deal with world animal agriculture and to contribute to the improvement of human welfare and social status all over the world (table 23). Their distinct objectives are different, but their roles are based on the philosophy already described. These organizations have been very useful to disseminate technical information and personal exchange programs in order to develop world animal production.

7) Promotion of international academic activities

Various regional scientific associations are currently undertaking scientific activities throughout the world. Some of examples are the World Association for Animal Production (WAAP), the Asian-Australasian

Association of Animal Production Societies (AAAP), the European Association for Animal Production (EAAP), and the Latin American Association of Animal Production (ALPA).

(1) Brief history of the WAAP:

In 1963, the first World Conference on Animal Production (WCAP) was held in Rome, organized by EAAP, under the patronage of FAO. The success of the conference encouraged closer collaboration between the animal production organizations in the world. In 1965, the World Association for Animal Production (WAAP) was officially established. One of main objectives of WAAP is to promote through international cooperation the WCAP for the purpose of reviewing scientific, technical and educational problems in world animal production, and develop other relevant activities in the world-wide interest of animal agriculture. The WAAP also collaborates with member societies for the exchange of information and initiating and organizing regional discussions, and meetings on problems related to regions. The summary of the past WCAP from the first in 1963 to the last conference in 1993 is shown in table 24.

(2) Characteristics and major activities of the 8th WCAP:

The 8th WCAP will be held at Seoul National University, Seoul, Korea from June 28 through July 4, 1998 with a theme of "Animal Production into the 21st Century for the Quality of Human Life".

The objective for the 8th WCAP is to focus attention upon the broad, global issues of animal production and animal sciences at the entry to the 21st century. The conference will provide a unique forum for these issues to be considered by scientists,

researchers, administrators, policy makers, teachers, and extension workers from all regions of the world. For these aims the 8th WCAP will provide various symposia, plenary & review sessions and contributed paper presentation sessions. In summary the 8th WCAP is not seeking to compete with the highly specialized, narrowly focussed and more frequently held regional and national animal production conferences. While offering the opportunity for papers on new research and application, the Conference targets the larger issues facing animal science in all regions and branches of the discipline.

One of the features of the 8th WCAP is a special symposium on "Livestock, Ethics and Quality of Life in the 21st Century". The Special Symposium will provide the opportunity to review the way that animal production and animal science must adapt to the changing human condition as mankind enters the 21st century. This Special Symposium will consist of specially prepared papers by a number of distinguished specialists from disciplines other than animal science and also by animal scientists representing different regions. These presentations will lead into extended and directed discussion. Speakers from different disciplines, including economics, ethics, rural development, sociology, political science, market development etc. will address the theme from the perspective of their professional fields.

ROLE OF ANIMAL AGRICULTURE IN THE 21ST CENTURY

1. Projection in numbers of human population and animals to be raised

As is seen in figure 5, world population was 2.5 billion in 1950 and this is projected to increase to 10 billion in 2050. This tremendous increase is likely to cause many problems in food supply. Maybe the production of crop and cereal can not satisfy the future demand, and it is hoped that the food of animal origin will contribute in solving some of these problems.

Table 25 presents the projection of world livestock number. According to projection, the world cattle number will slightly decrease, but chicken number steadily increase in the future. And, in developing countries, the animal growth rate of all animal species is higher than in developed countries.

Over the past two decades, the growth rate of animal numbers was lower in developed countries than in developing countries, which means that the number of animals reached a balance with market demand in developed countries, and increased numbers of animals can be expected mainly in developing countries in the coming century, as depicted in table 26. The growth

of cattle, buffalo, sheep and goat numbers in 93 most developing countries is expected to be low during the period 1990-2010. On the other hand, the number of pig and poultry will grow at a constant rate, especially in Sub-saharan Africa and the Near East/North Africa area.

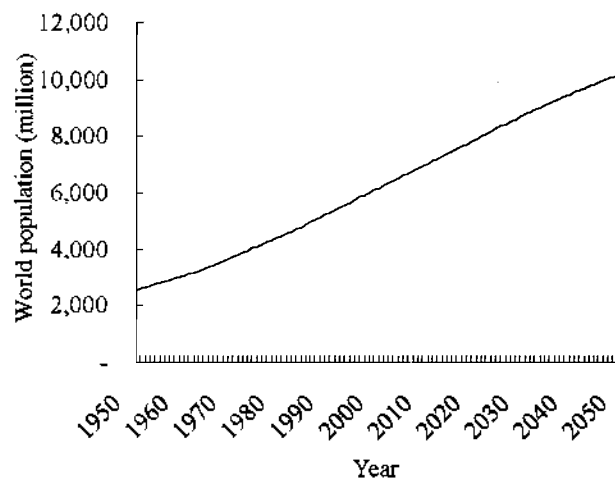


Figure 5. Trend of world population to 2050 (Source : FAOSTAT, 1998)

Table 25. Projection of world livestock numbers (unit : million head)

Item	1970	1995	2020	Annual Growth (%)	
				70-95	95-2020
World					
Cattle	1,082	1,310	1,195	0.8	-0.4
Pig	546	905	1,411	1.9	1.8
Chicken	5,215	12,607	20,660	3.6	2.0
Developed countries					
Cattle	388	367	349	-0.2	-0.2
Pig	261	303	421	0.6	1.3
Chicken	2,950	4,076	5,388	1.3	1.1
Developing countries					
Cattle	694	943	1,146	1.2	0.8
Pig	284	602	889	3.1	1.6
Chicken	2,266	8,531	12,272	5.4	1.5

Source : FAOSTAT, 1998 ; FAO, 1996.

2. Projected production of animal products

As was last two decades, the annual growth rate of all animal products in developing countries will be a higher than in developed countries, especially in chicken meat, upto 2020 (table 27). This means that the number of animals raised in developing countries

will increase and the production efficiency of animal will be improved, which are resulted from brilliant advances of biotechnology.

Table 26. Projection of animal numbers in developing countries (unit : million head)

Item	1970	1990	2010	Annual Growth (%)	
				70-90	90-2010
93 developing countries					
Cattle & buffalo	798	1,005	1,369	1.2	1.6
Sheep & goat	869	1,129	1,578	1.3	1.7
Pig	291	486	860	2.6	2.9
Poultry	2,504	6,469	12,318	4.9	3.3
Sub-Saharan Africa					
Cattle & buffalo	129	159	200	1.1	1.2
Sheep & goat	203	259	344	1.2	1.4
Pig	6	11	16	3.1	1.9
Poultry	339	630	1,097	3.1	2.8
Near East/North Africa					
Cattle & buffalo	37	37	52	0.0	1.7
Sheep & goat	203	240	326	0.8	1.5
Poultry	206	677	1,125	6.1	2.6
East Asia					
Cattle & buffalo	118	153	332	1.3	3.9
Sheep & goat	157	220	371	1.7	2.6
Pig	216	388	727	3.0	3.2
Poultry	1,178	3,335	7,415	5.3	4.1
South Asia					
Cattle & buffalo	293	335	419	0.7	1.1
Sheep & goat	148	247	337	2.6	1.6
Pig	7	11	14	2.3	1.2
Poultry	235	571	857	4.5	2.1
Latin America/Caribbean					
Cattle & buffalo	218	319	364	1.9	0.7
Sheep & goat	152	153	187	0.0	1.0
Pig	63	75	103	0.9	1.6
Poultry	546	1,256	1,822	4.3	1.9

Source : Alexandratos, 1995.

The projection of production of animal products (table 28) shows nearly the same tendency as animal numbers. But the growth rate of mutton and goat meat production in 1990-2010 is anticipated to be higher than during the period of 1970-80s. In developing countries, more dramatic increases in the production of beef, buffalo meat, mutton and goat meat are expected compared to the past two decades. However, the growth of pork, poultry meat and milk production is projected to be less than that of 1970-80s.

In case of beef, China is expected to have the fastest growth rate, reflecting demand which encourages more production. Increased demand in the former Soviet Union and Brazil is also expected to result in stimulated production. However, declining production in the EU, as beef consumption falls will

affect the global rate of expansion.

Table 27. Past and projected production of animal products (unit : 1,000 MT)

Item	1970	1995	2020	Annual Growth (%)	
				70-95	95-2020
World					
Beef	38,337	53,333	82,265	1.3	1.7
Pork	35,777	83,129	125,638	3.4	1.7
Chicken meat	13,140	46,602	86,076	5.2	2.5
Eggs	20,464	47,261	92,754	3.4	2.7
Milk	391,821	537,821	761,721	1.3	1.4
Developed countries					
Beef	27,293	31,397	41,226	0.6	1.1
Pork	25,930	36,173	49,422	1.3	1.3
Chicken meat	9,811	23,387	39,177	3.5	2.1
Eggs	14,974	17,703	22,526	0.7	1.0
Milk	311,323	346,363	680,309	0.4	0.9
Developing countries					
Beef	11,043	21,945	41,039	2.8	2.5
Pork	9,847	46,955	76,216	6.4	2.0
Chicken meat	3,329	23,216	46,902	8.1	2.9
Eggs	5,490	29,557	70,228	7.0	3.5
Milk	80,500	191,458	281,412	3.5	2.2

Source : FAOSTAT, 1998 ; FAO, 1996.

World pork production is projected to increase at a slower rate than in previous decades as environmental constraints limit expansion in many areas and larger amounts of relatively cheaper poultry meat will also compete with pork. Asia and Mexico are the primary areas for expansion in pork production. It is projected that more modest production increases will occur in the United States, Canada, the former Soviet Union and Central and Eastern Europe, while pork production in Japan will likely decline.

World production and consumption of poultry meat will continue to expand. The combination of low production costs compared with most other meats and the projected economic growth in most areas of the world will boost the demand for this product. In many developed countries, dietary concerns and health issues will also help to increase the demand for poultry meat. The United State is the largest poultry meat producing country and accounted for nearly one quarter of world production in 1996. The next largest exporters are the EU, China and Brazil. Production in these countries is projected to rise continuously as demand expands.

3. World per capita consumption of animal products in the future

Table 29 presents the projection of world per

capita consumption of animal products. During the last two decades of per capita animal products consumption in developing countries increased by 3.46% on average. Especially, the consumption of poultry meat, egg and pork was rapidly expanded. Although the future growth rate is projected to be lower than this century, the consumption of animal products will increase continuously up to 2020.

Table 28. Projection of animal products in developing countries (unit : million MT)

Item	1970	1990	2010	Annual Growth (%)	
				70-90	90-2010
93 developing countries					
Beef & buffalo meat	12.1	18.6	32.3	2.2	2.8
Mutton & goat meat	3.0	4.9	9.5	2.5	3.4
Pork	9.7	28.3	64.0	5.5	4.2
Poultry meat	3.7	12.9	36.9	6.4	5.4
Sub-Saharan Africa					
Beef & buffalo meat	1.7	2.3	4.2	1.5	3.1
Mutton & goat meat	0.7	0.9	1.8	1.3	3.5
Pork	0.2	0.3	0.8	2.0	5.0
Poultry meat	0.3	0.9	2.2	5.6	4.6
Near East/North Africa					
Beef & buffalo meat	0.8	1.4	2.4	2.8	2.7
Mutton & goat meat	1.0	1.4	2.7	1.7	3.3
Poultry meat	0.4	1.6	4.6	7.2	5.4
East Asia					
Beef & buffalo meat	0.9	2.3	6.4	4.8	5.3
Mutton & goat meat	0.3	1.1	2.0	6.7	3.0
Pork	7.3	24.6	57.2	6.3	4.3
Poultry meat	1.6	5.1	17.3	6.0	6.3
South Asia					
Beef & buffalo meat	1.8	2.6	4.5	1.9	2.8
Mutton & goat meat	0.5	1.1	2.3	4.0	3.8
Pork	0.2	0.4	0.6	3.5	2.0
Poultry meat	0.2	0.5	2.0	4.7	7.2
Latin America/Caribbean					
Beef & buffalo meat	6.9	10.0	14.8	1.9	2.0
Mutton & goat meat	0.5	0.4	0.7	-1.1	2.8
Pork	1.9	3.0	5.3	2.3	2.9
Poultry meat	1.2	4.8	10.8	7.2	4.1

Source : Alexandratos, 1995.

It is surprising to note that per capita consumption of meat of China was much lower than the world average until 1990. However, it is predicted to be much higher than the world average up to 2020, as is seen in figure 6.

On the other hand, increases in per capita consumption in developed countries will be much lower (less than 0.5% per annual) compared to developing countries, which is far lower than developed countries in 1975-95. Declining per capita consumption rate, moderate income growth and

increasing health concerns are likely to limit any expectation for significant increases in total production of animal products in the developed countries, and the tendency is expected to continue toward 2020. Similar data can be seen in table 30, which presents projection on growth of different types of meat over 1990-2020 period.

Table 29. Projection of world per capita consumption of animal products (unit : kg/capita/year)

	1970	1995	2020 ¹	Annual Growth (%)	
				70-95	95-2020 ¹
World					
Beef	10.7	9.7	11	-0.4	0.5
Pork	9.5	14.6	15	1.7	0.1
Chicken meat	4.0	9.5	11	3.5	0.6
Egg	5.1	7.3	9 ²	1.4	0.8
Milk	73.0	76.3	83	0.2	0.3
Developed countries					
Beef	26.1	23.7	25	-0.4	0.2
Pork	23.3	27.9	29	0.7	0.2
Chicken meat	10.2	20.7	24	2.9	0.6
Egg	12.8	12.1	13 ²	-0.2	0.3
Milk	181.4	194.9	198	0.3	0.1
Developing countries					
Beef	4.3	5.6	7	1.1	0.9
Pork	3.7	10.7	13	4.3	0.8
Chicken meat	1.5	6.2	8	5.8	1.0
Egg	1.9	5.9	8 ²	4.6	1.2
Milk	28.2	41.3	48	1.5	0.6

Source : FAOSTAT, 1998; ¹ Rosegrant et al., 1997; FAO, 1996; ² projected.

Table 30. Expected growth of different types of meat

Product	Total Growth (%) over 1990-2020	
	Developing World	Developed World
Beef	101-170	11-14
Pork	131-225	12-16
Poultry meat	126-211	30-31

Source : Sere and Steinfeld, 1996; IFPRI, 1995.

4. Global production of cereals and crops

Total production of cereals and per capita production is given in table 31. During 1990-2010, the growth rate of total cereal production is projected to increase up to 2.02% in developing countries. But world per capita production will not increase toward 2010. This means that the production of cereals cannot catch up with the increase of human population, which will result in food shortages and malnutrition problems in many areas of the world in the coming 21st century.

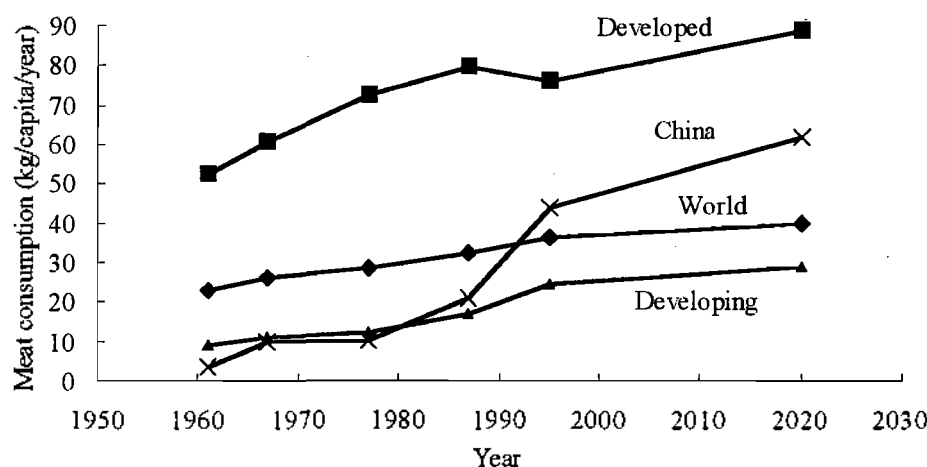


Figure 6. Trends in meat consumption for China (Source : FAOSTAT, 1998)

Table 31. Total and per capita production of cereals, past and projections

Item	Total Production (million MT)				
	1980	1990	2010	Annual Growth (%)	
				80-90	90-2010
World	1,477	1,756	2,334	1.75	1.43
Developed	793	873	1,016	0.97	0.76
Developing	651	883	1,318	3.10	2.02

Item	Per Capita Production (kg)				
	1980	1990	2010	Annual growth (%)	
				80-90	90-2010
World	325	326	326	0.03	0.00
Developed	678	692	722	0.20	0.21
Developing	200	214	229	0.68	0.34

Source : Alexandratos, 1995.

Table 32. Past and projected trends of cereals as feed to the year 2020 (unit : million MT)

Item	1983	1993	2020	Annual Growth (%)	
				83-93	
				83-93	93-2020
World	579	637	927	1.0	1.4
Developed	453	443	536	-0.2	0.7
Developing	126	194	390	4.4	2.6

Source : Rosegrant et al., 1997.

Table 33. Regional growth estimates (%) for cereals and meat over the period 1990-2020

Region	Cereal	Meat
World	49-65	60-90
Developed countries	19-33	17-18
Developing countries	68-91	123-206
Sub-saharan	136-161	141-194
Latin America	53-77	76-105
West Asia/North Africa	74-100	104-157
Rest of Asia	64-85	148-255

Source : IFPRI, 1995.

Table 32 reveals the past and projected trends in cereal production as animal feed. In developing countries, annual growth of cereal usage as feeds is higher than developing countries, and this trend will be continued until 2020.

Comparison of regional growth estimates for cereals and meat over 1990-2020 is presented in table 33. As mentioned above, the developed countries almost already reached stability in demand for meats and cereals, but the demand for cereals and meats are expected to increase in developing countries further.

5. Global trade projection of selected meat and crop

Past and projected real prices of selected crop, livestock products and fisheries are presented in table 34. The price of crops has steadily fallen, and livestock products also show a slight decrease. According to the projections both by the World Bank and Rosegrant et al. (1997), the projected prices for crops, livestock products and fisheries will fall continuously.

Tables 35, 36 and 37 present beef, pork and poultry meat trade projections of the world. Traded beef, although growing in importance, accounts for a relatively small portion of global consumption. However, for a number of countries, especially those with increasing incomes and limited agricultural resources, imported meat products comprise important portions of total meat consumed. Increasing demand for imported meat in areas like the Pacific Rim and in countries such as Russia, where production has been adjusting to market forces, will provide good growth opportunities for exporters. The production in major exporting countries will continue to grow for export, while domestic production in the major

Table 34. Past and projected trends in real prices of selected crop, livestock and fisheries exports

Year	Wheat	Rice	Corn	Soybeans	Soymeal	Fishmeal	Beef	Pork	Poultry	Lamb
(constant 1990 US\$/MT)										
1970-2	232	524	215	476	415	750	5,144	n/a	n/a	3,248
1980-2	236	534	169	384	338	615	3,536	2,344	1,474	3,730
1990-2	135	288	104	234	195	444	2,585	1,781	1,139	2,440
1993-5	139	284	99	229	179	367	2,060	n/a	1,100	2,395
World Bank projections										
2000	135	279	102	230	189	n/a	1,773	n/a	n/a	n/a
2010	118	262	92	236	196	n/a	1,629	n/a	n/a	n/a
Rosegrant et al. projections										
1992-4	148	286	126	263	n/a	n/a	2,023	1,366	1,300	2,032
2010	145	305	126	255	n/a	n/a	1,929	1,330	1,232	1,986
2020	128	260	121	250	n/a	n/a	1,919	1,288	1,248	1,923

Sources : Delgado and Rosegrant, 1997; n/a : not available.

importing countries is projected to decline or maintain current production, mainly because of the relatively lower cost of imported beef. Growth in beef exports is projected to be low as subsidized exports by the EU fall, in keeping with commitments under the Uruguay Round. The EU, however, is the only major exporter that shows a decline in beef exports. The United States, Australia and Argentina are projected to increase export volume through 2005.

Table 35. Beef trade baseline projections (unit : 1000 MT, carcass weight)

Country	1997	2000	2005	Annual Growth (%)
Importers				
United States	930	1,154	1,255	3.82
Japan	985	1,093	1,211	2.62
South Korea	240	362	512	9.93
Taiwan	69	87	115	6.59
European Union ¹	364	350	350	-0.49
Russia	625	507	660	0.68
Eastern Europe	93	112	132	4.47
Mexico	110	215	267	11.72
Canada	200	174	157	-2.98
Major Importers	3,616	4,054	4,659	3.22
Exporters				
United States	1,010	1,106	1,339	3.59
Australia	1,155	1,256	1,316	1.64
New Zealand	490	494	489	-0.03
European Union ¹	677	817	817	2.38
Eastern Europe	118	155	219	8.04
Ukraine	160	180	247	5.58
Argentina	480	473	527	1.17
Brazil	360	363	403	1.42
Canada	310	317	336	1.01
Major Exporters	4,760	5,161	5,693	2.26

Source : FAOSTAT, 1998; ¹ Excludes intra-EU trade, covers EU-15.

Table 36. Pork trade baseline projections (unit : 1000 MT, carcass weight)

Country	1997	2000	2005	Annual Growth (%)
Importers				
United States	274	271	254	-0.94
Japan	857	993	1,126	3.47
Hong Kong	189	236	250	3.56
South Korea	75	75	78	0.49
Russia	565	539	502	-1.47
Mexico	55	80	124	10.70
Canada	50	63	67	3.73
Major Importers	2,065	2,257	2,401	1.90
Exporters				
United States	483	508	633	3.44
Canada	360	426	443	2.63
European Union ¹	561	583	603	0.91
Eastern Europe	238	266	216	-1.21
Taiwan	360	339	306	-2.01
Canada	250	250	256	0.30
Major Exporters	2,252	2,372	2,457	1.09

Source : FAOSTAT, 1998; ¹ Excludes intra-EU trade, covers EU-15.

World pork trade is projected to be expanded, driven by rising demand in several of the major pork importing countries, including Mexico, Japan and Hong Kong. The former Soviet Union and Central and Eastern Europe will have a significant, although somewhat variable, influence on the world market. The United States is projected to keep a dominant role in the global market of the future.

Global trade in poultry meat is projected to rise at 4% per year to over 7 million tons by 2005. This is a tendency to slow-down from the high growth rates of the 1980s. Increases in imports are anticipated in all the largest importing markets, including China, Japan, Hong Kong, the former Soviet Union, Mexico,

Canada and the Middle East.

Table 37. Poultry trade baseline projections (unit : 1000 MT, carcass weight)

Country	1997	2000	2005	Annual growth (%)
Importers				
Russia	975	1,009	1,043	0.85
European Union ¹	214	194	150	-4.34
Japan	534	639	755	4.42
Hong Kong	920	1,005	1,165	3.00
China	900	1,169	1,518	6.75
South Korea	44	48	65	5.00
Saudi Arabia	247	209	270	1.12
Egypt	5	6	49	33.02
Mexico	190	211	225	2.14
Canada	75	84	90	2.31
Major Importers	4,104	4,574	5,330	3.32
Exporters				
United States	2,641	3,013	3,640	4.09
Brazil	580	697	901	5.66
European Union ¹	908	650	650	-4.09
Hungary	110	74	106	-0.46
China	600	670	869	4.74
Hong Kong	660	750	910	4.10
Thailand	167	165	168	0.07
Saudi Arabia	35	42	67	8.46
Major Exporters	5,701	6,061	7,311	3.16

Source : FAOSTAT, 1998; ¹ Excludes intra-EU trade, covers EU-15.

* The projection (Table 35, 36 and 37) were completed in Nov. 1996 based on policy decisions and other information known at that time.

6. Role of animals in the future

Ever since domestication, animals have served many different functions for human beings. First, animals provided many different types of valued commodities such as meat, egg, milk, wool, fur etc. Food of animal origin has served as a high quality protein source for humans during the whole human history.

Another resource we obtain from animals is "work". The term "work" is used here to denote contributions of animals for draft, packing, riding and herding. Animals have provided draft power until machines powered by fossil fuels become widely used. Nevertheless animals are still a very important source of power for agricultural purposes and for transportation of goods and people in most developing countries. Today, animals also provide many other services. Guiding the blind, protection, hunting and companionship are some of examples (figure 7).

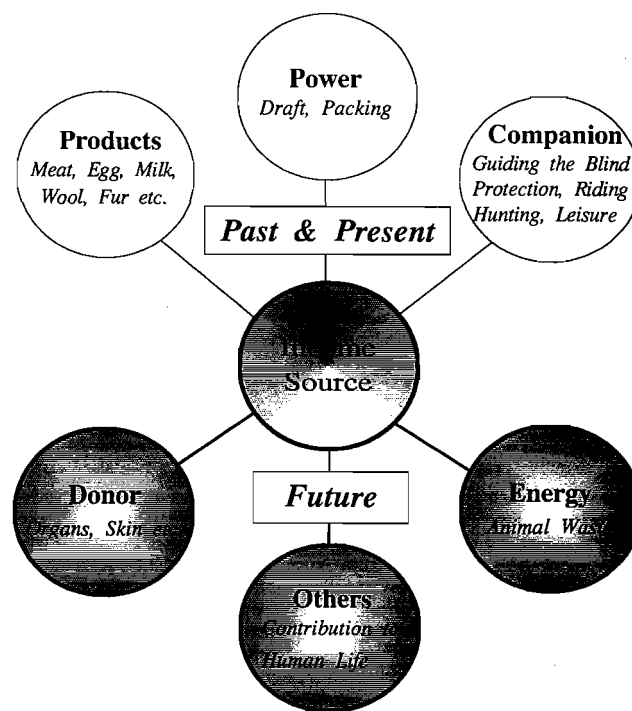


Figure 7. Role of animals in the future

Animals will play a key role in the quality of human life in the future, too, as they did in earlier days. In the near future, with the technological advances in the field of life sciences, animals will become donors of organs, skins and other products, or as producers of drugs or special functional foods.

CONCLUSION

The increasing role of animal agriculture for the quality of human life has always been emphasized during 20th century and it is expected to be even more important in terms of food supplies and in providing additional functions in the future. Available statistics reveal that the world human population has almost tripled during a period of half century. Also the world population of cattle, buffaloes, sheep, goat and pigs has increased 2~3 times during last the 60 years period, and chickens have increased by 6 times. The total amount of livestock products produced in the world during recent several decades has also increased 5~6 times and more than 10 times in the case of pork. It should be noted that developing countries produced more animal products with higher annual growth rate than countries in developed region. Especially, the production of pork in developing countries has been with 9% of annual growth.

Performance of most of major animal species in developed countries has improved remarkably throughout this century. Average daily gain of beef cattle during the last half century were almost doubled

from 604 g/day in 1940s to 1,348 g/day in 1990s, and feed efficiency was improved by 70% during this period. Milk production increased from 3,466 kg/year in 1920s to 11,844 kg/year in the 1990s. Average daily gain of pigs in the 1940s was 580 g/day and increased to 870 g/day in the 1990s. Feed efficiency of pigs also improved from 0.28 to 0.37 during the same period. Similar improvements in growth rate, and feed conversion rate were also found in chicken production. Laying hens in the 1990s produced almost 2 times more eggs than in the 1920s.

Increased personal income certainly encouraged demand for animal products over grains and lower animal production costs resulted from scientific and technological advances. It is interesting that the increasing rate of per capita consumption of animal products including milk and fish in developing countries is higher than in developed countries. Considering the increase in consumers prices of other commodities during the 20 century, the relative price increase of animal products has been low, although the prices of animal products have gone up gradually.

Similar contributions are expected from animal agriculture in the coming century. The production of total grains, in general, in all countries has more than doubled owing to the advances of agricultural science during the later part of the 20th century. The life span of people in the world has steadily increased throughout the 20th century. The average life span of world people in 1950s was only 46 years, which will be increased to almost 66 years in the year 2000. Present data clearly indicate that the life span of people is proportional to their income (GNP) and/or animal protein intake. People in most developed countries tend to consume more protein of animal origin and live longer than people in developing areas.

Animals can provide other resources than foods. They have been used as a source of power for transportation and cultivation. Dogs have been used for herding, guiding or as companion animals throughout the history of mankind. Animals can also be utilized for sports, leisure and comfort mainly as companion animals which will become one of most important roles of animals after supplying foods. It may be concluded that animals are every closely associated and related to the quality of human life, and they are expected to remain the same way in the 21st century.

Animal scientists have made tremendous advances in terms of science and technology for efficient animal production in the 20th century. Some important contribution achieved during current century may be listed as follows : Gene mapping & animal genetic resources, biotechnology, recycling & treatment of animal waste, animal welfare, processing technology of animal product and use of metabolic active substances and synthetic amino acids. Most academic society and

scientific journal were founded in this century with only a few having been founded in the previous century. Publication of scientific papers contributed substantially to the advancement of academic quality. Most leading universities and research institutes founded in this century. Various international organizations were established during later part of this century to deal with world animal agriculture and to contribute to the improvement in quality of human life.

World population is projected to increase up to 10 billion by 2050. It is evident that numbers of animals to be raised will also be increased in the 21st century. It is projected that the growth rate of world animal numbers will be lower in developed countries than in developing countries in the coming century. For example, animal production will be rapidly increased in P.R. China to meet their per capita consumption of animal productions. In developing countries, more dramatic increase in the production of beef, buffalo meat, mutton and goat meat is expected. Per capita consumption of animal products will be continuously increased up to 2020. Expecially, consumption of poultry meat, egg and pork will be rapidly expanded, although the growth rate is projected to be lower than this century. During 1990~2010, the growth rate of total cereal production is projected to increase upto 4.9% in developing countries. However, projected data indicates that world per capita production of cereals will not be increased toward 2010.

With regard to the projection of global beef trade, there will be increasing demand for imported beef in the areas like the Pacific Rim and in countries such as Russia where production has been adjusting to market forces and this will provide good opportunities for exporters. World trade in pork and poultry meat is projected to expand. It appears that Mexico, Japan, Hong Kong, Russia, Central & Eastern Europe, China and some other countries may be importing, and the US will export animal products in the future.

The other resources we get from animals are drafts, packing, riding, hunting and herding. Guiding the blind, protection and companionship are also examples of what we can expect from animals. Animals will play a key role for the quality of human life in the future, as they did in earlier days. In the very near future, animals will become major donors of organs, skins and producers of drugs or special functional foods.

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