Implications of the decline in world oil reserves for future world livestock production

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Summary

In the near future, a reduced availability of primary resources as well as environmental, ecological, social and political issues will have major effects on rural development. Escalating costs of fossil fuel will precipitate a cascade of environmental, economic, political and cultural changes for which society is unprepared. The energy supply–demand deficit has the potential to eclipse climate change as the driving force for sustainable development. In the future, fuel and other costs of crop production will be included in the sale price of products and agricultural land use patterns will move to towards cropping for alcohol, biomass and bio–fuel production, particularly in the industrialized world. Competition for grain between food for humans, feed for livestock, feedstock for fermentation industries will intensify and the use of more expensive cereal grains for livestock production will need to be substantially reduced. Accordingly, meat protein will be derived less from industrialized pig, poultry and feedlot cattle enterprises and more from ruminants nourished by forages and by–products of crop production. Developing countries will require a non–fossil–fuel dependent development strategy, which will mean that their societies will be organized very differently. Food production will come increasingly from smaller, more localized and decentralized communities with mixed farms (producing multiple crops, animals, birds and fish) rather than specialized farms producing only a few products.

Keywords: alcohol, bio–fuels, cereal grains, industrial agriculture, oil production, rural development

Introduction

Planet earth is under a number of interacting stresses brought about by human activity. If humans are to continue to develop–or merely exist–a major adjustment of people's activities will be needed. Major stresses include:

- Pollution and climate change with potentially abrupt environmental warming;
- Scarcity of fuel or renewable energy that can be harnessed to replace fossil fuels: oil production will peak (or has peaked) and world supplies will start to decline with massive effects on human activity;
- Scarcity of water: 60% of the world's people are likely to have insufficient water by 2025. Water for irrigation will limit food production;
- Loss of biodiversity and extinction of large numbers of organisms;
- A continuing population increase, mainly in the resource poor countries.

Over the past 20 years, global warming has become increasingly recognised as potentially the greatest threat to the wellbeing of humans. However, the phenomena known as 'peak oil'(see following discussion), barely recognised or stuck in 'the too hard basket' by politicians, scientists and world leaders, is now creating shock waves through the world's economy. In the short term, the outcomes from peak oil may reduce the commitment by governments to greenhouse gas abatement policies. It appears that the potentially high cost of energy will become a major driving force for sustainable development. As many aspects of human life are dependent on liquid fuel sources, the coming oil crisis will affect all segments of a country's economy and in particular on agriculture and animal farming. The decline in available fuel and the subsequent rise in price will precipitate a cascade of environmental, economic, political and cultural change for which we are unprepared.

To date, humans have been able to expand their population and their standard of living by:

- Increasing the available resource base in terms of energy, water, land and food;

- Minimising and reducing colonisation. Although there is still an enormous, inequitable use of resources, particularly oil, when the rapidly industrialising countries obtain a greater share of these resources, price of oil and everything that requires its use must again escalate;
- Containing pestilence. Some disease pandemics, particularly in the developing countries, however, may be uncontrollable (e.g., HIV and SARS) without massive assistance from the industrialised world;
- Controlling localised pollution. Greenhouse gases are expected to increase and have major impacts, particularly on the cost of fossil fuels.

Limits to human population growth have been proposed over the years but human ingenuity has overcome these limitations as they have arisen. The standard of living has increased in general, but disproportionately both within and between countries. Can all this continue?

In terms of future development, the availability of fossil energy resources is a major factor. Those countries and governments that had early access to these inexpensive energy resources were able to develop their economies rapidly. The availability of cheap energy has allowed many of the commodities of life to be produced at low cost. This applied particularly to food production. For example, grain production could be highly mechanised with fewer people needed in food production at a high cost of the use of fuel (see Table 1). With the advent of high yielding cereal varieties, world grain production increased four–fold, but only with a massive increase in the use of fossil fuels and electricity, especially for fertilizer production. Efficient manufacturing took people away from agriculture; the resultant wealth was partially used to subsidise food production (to keep grain prices low), which together with cheap energy facilitated the intensification of animal production.

The link between inexpensive fuel and inexpensive food is undeniable. For example, the more developed the country, the greater the fossil fuel input into cereal grain production (Figure 1); yields increased but at a greater cost of fuel per unit of production (Table 2). Industrialised agriculture requires far fewer people than small farm operations in developed countries (Table 1).

Peak oil and the inability of the oil industry to meet world demand and therefore subsequently inflated oil prices provide the potential for political neglect of environmental aspects (e.g., increased use of coal for electricity generation rather than use of more expensive renewable energy). This is likely to increase conflict between oil rich and oil poor countries (predation as a grab for fuel) and could trivialize the prevention of pestilence (e.g., AIDS) and increase the poverty status of the poor in developing countries, who have very low incomes and are unable to take advantage even of cheap oil (e.g., the need for cooking fuel may increase the rate of deforestation in countries such as Nigeria). Countries with emerging economies will need to draw on cheap labour to lower the effects of expensive fuel in order to continue their economic growth.

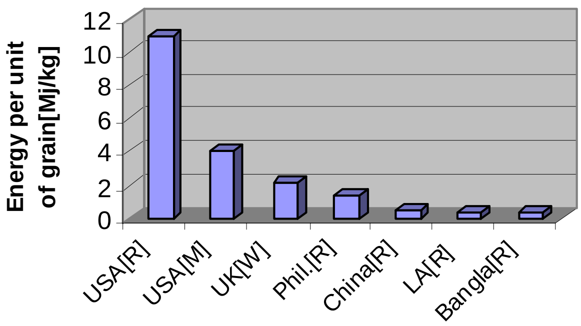

Figure 1 Energy input per unit of grain production in some selected industrial countries and developing nations (Pretty, 1995).

Table 1 Energy use by developed and developing countries in relation to numbers of people working in agriculture (Pimentel *et al.* 1988).

Country	Energy use (10^{12} kcal)	*Per capita* use (10^6 kcal)	% population in agriculture
USA	18400	77	2.6
Brazil	600	4	37
India	900	1	62
Kenya	12	0.6	75

Table 2 Grain yields and energy inputs in modern and traditional agricultural (Pimentel 2001).

	Non–mechanised agriculture (Developing countries, e.g., Mexico)	Mechanised agriculture (Industrialised countries, e.g., United States)
Energy inputs (MJ/ha)	2318	35132
Grain yield (MJ/ha)	28895	60025
Grain yield (kg/ha)	1944	7000
Energy ratio (energy in grain per unit energy input)	12.5:1	2.9:1

The decline in oil: a major factor limiting food and feed production

The world is not running out of oil–the world is running out of inexpensive oil. Cheap oil fuelled the economic development (miracle?) of the industrialised nations in the 20th century. This applies in particular to the USA, which has appropriated oil at a faster rate than any other nation and has the highest conversion rate of oil to food in the world.

Because the USA produces 5% of the world's oil but consumes about 30%, the USA will need to reduce oil use by at least 5% per anum for there to be any prospect for developing countries to secure an equitable proportion of the remaining oil. On average, most of the developing countries are self–sufficient in food production but the margins of production are finely balanced. World surplus grain has been traditionally available when calamities result in potential famines. North America (USA and Canada) is the major world food exporter and this has immense implications for the rest of the world. As liquid fuel supply decreases relative to demand, industrialised countries and many others will reduce their inputs into food production and increase their inputs into feedstock production for the bio–fuels industry, including fuel alcohol and bio–diesel production.

Oil as a finite resource

Fossil fuel reserves were deposited from the residues of algae growing in warm shallow seas followed by burial as the sea floor sank and the debris was heated by the earth's heat flow over hundreds of thousands of years. World oil deposits occur in only a few of the potentially oil–bearing geological provinces. Most of these areas have been mapped and there is reliable information on the state of world reserves before exploitation and at the present time (Fleay 1995).

World total oil resources other than those in inaccessible deep–sea areas or in tar sands are estimated to be close to 2000 billion barrels. These calculations are based on oil that has already been extracted plus estimated reserves in known fields and a prediction of fields yet to be discovered. The 'yet to be discovered' oil will be in the most difficult sites to mine (polar and deep–sea sites) and therefore this oil is recognised as a high priced resource (Fitzgerald 2005).

There are potentially 3000 billion barrels of oil in tar sands and shale deposits, mainly in the USA and Canada (Johnson *et al.* 2004). Exploitation of this non–conventional oil is difficult and hazardous, as it requires a considerable amount of water, is energy–expensive to extract and is highly polluting. It would appear that two barrels of conventional oil are required to extract three barrels of oil from shale deposits effectively (Younquist 1997). These reserves will certainly be mined in the future but with a long lead–time. Optimistic estimates suggest that shale oil will be a 'two million barrel per day industry' in the USA by 2020 (Johnson *et al.* 2004). This is less than 2% of the projected world requirement for oil, but 10% of USA consumption at present.

The Hubbert Peak of oil resource exploitation

Following discovery of oil and establishment of facilities, the rate of extraction of oil increases until a peak is attained and then falls. This is known as the Hubbert Peak and is bell–shaped. The peak extraction rate is always close to the mid point of depletion and has become known as peak oil (Hubbert 1949). In the USA, the rate of discovery of oil peaked in 1930. From this and the depletion curves for oil wells, Hubbert predicted that oil production in the USA would peak in 1970 and decline thereafter (Hubbert 1956). At that time, this concept was universally ridiculed but USA (lower 48 states) oil production peaked and began to fall in 1971–1972 (Campbell and Leherrere 1998).

The reality of the Hubbert Peak appears has now been accepted by the petroleum industry and is being used by resource scientists and economists to predict world oil reserves and their likely depletion rates. This is discussed by Fleay (1995), Campbell (1997), Youngquist (1997), Deffeyes (2001) and Roberts (2004). Oil discoveries worldwide peaked in the mid 1960s and have since declined. It is estimated that world peak oil will occur in 3 to 10 year's time (Figure 2).

The world has been using oil at a greater rate than the discovery rate (Figure 3); for every new barrel discovered the world is currently using 4–6 barrels. During the past two years, the discovery rate for new oil has only been about 10–20 billion barrels despite highly sophisticated and accurate methodology for identifying geological formations where oil and gas have accumulated. Discoveries of oil fields with capacities of more than 500 million barrels of oil were frequent a few years ago but no discoveries of this size have been made since 2002 (there were two in 2002, six in 2001 and 13 in 2000). It is widely publicised that the net value of all discoveries for the five major oil groups during the three years, 2001–2003, was less than the exploration costs (Duffin, cited by Ruppert 2005).

Australia's oil vulnerability

It is possible to predict ultimate oil resources (referred to as The Ultimate) and their depletion rates from the characteristics of the Hubbert Peak. As Ruppert (2004) recently stated, "The subject of peak oil requires a little study to get your brain around it. However, it does not need much science except basic arithmetic." Oil use in the world has increased to about 80–82 million barrels/day or 1 billion barrels every 12 days. Conservative estimates indicate that demand will rise to 90–100 million barrels/day by 2010 (McKillop 2004a).

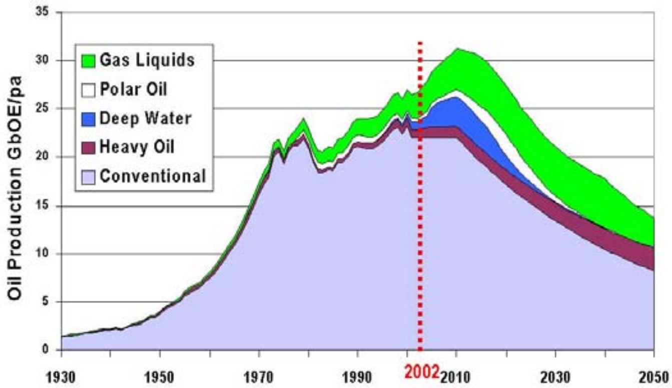

Figure 2 Forecast of world oil production, including non–conventional oil (Campbell 2000).

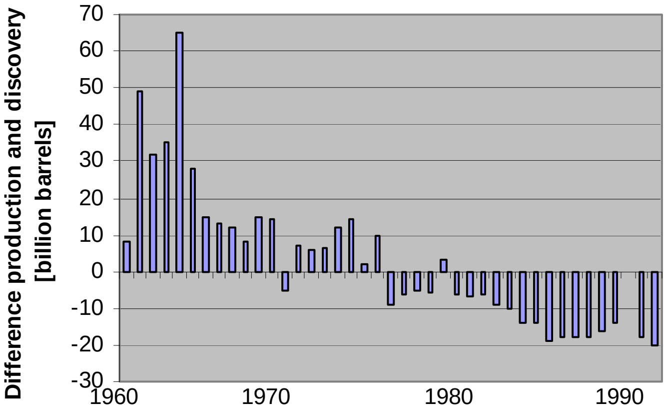

Figure 3 The difference in the rate of discovery of oil and the rate of oil use in the world (Campbell 2001). Negative values indicate years during which less oil was discovered than was used.

All the major oil fields were discovered long ago; most have exceeded Peak Production and are in decline. According to Magoon (2001), world production peaks are: North American fields (including those in Alaska and Mexico), 1984; the former Soviet Union, 1987; Europe, 2001; Africa, 2001; Asia–Pacific, 2003; South and Central America, 2005; Middle East, 2010. The discovery of large oil fields (i.e., those with a capacity of more than 0.5 billion barrels or 60 days of the world requirement) has dwindled to zero. Small finds are occurring but not at a sufficient rate; global oil production capacity is contracting by over 1 million barrels each day every year.

Peak oil production (including new oil finds) is predicted to be 90–92 million barrels/day and world production should soon start trending downwards (Deffeyes 2001). The spare capacity for pumping oil, which is largely in the Middle East and Russia at present, is approximately 2–3 million barrels per day but considering the numerous factors that can interfere with supply (e.g., war, terrorism and sabotage of oil supply lines, clogged shipping routes, high freight charges, lack of refinery facilities, lack of tankers and political action), the potential is unlikely to be realised.

Demands for oil, particularly by China, India, Pakistan and some Latin American countries are increasing at unprecedented rates. Global demand is expected to increase by at least one million barrels every day each year. It appears inevitable that fuel will be scarce and expensive in years to come.

There is great concern among investment bankers that lack of transparency in reporting oil reserves in some countries may obscure an imminent and cataclysmic fall in world oil reserves (Simmons 2002; Schempf 2004; Ruppert 2004; Roberts 2004). The problem can be summarised as follows:

- The Middle East has 75% of the world's remaining oil;
- Ghawar (Saudi Arabia) had 100 billion barrels of reserves (only one field of this size has ever been discovered) and dominates the Saudi capacity to produce oil;
- Ghawar has been geared from its beginning (1948) to maintain high flow rates by pumping in seawater to lift the oil, and it is now 50 years since tapping at a significant rate began;

- Ghawar is now pumping a mix of 55% water and 45% oil;
- Experience shows that when the water content of the liquid at the head exceeds 70–80%, a field collapses much more rapidly than indicated by the Hubbert model. Ismail (1993) from an in–depth study of the capacity expansion of Gulf fields claimed that Ghawar was in decline then, supporting the belief that Ghawar's reserves have been overestimated and the wells could soon enter a serious decline.

The major conclusion is that if this mega–field of Saudi Arabia has peaked, the date for world peak oil may have already occurred. Predictions of the year of peak oil by experts are summarised by Johnson *et al.* (2004) and Magoon (2001), and vary from 2000–2020. Most recent reports suggest 2007–2008 will be the beginning of the major decline in oil availability (Ruppert 2004; Fitzgerald 2005).

McKillop (2004b) summarised the world oil situation by stating, "World oil demand increase in the coming years (to 2010) will not be less than 1.75 million barrels/day, barring world wide economic recession through use of interest rate weapons as a response to runaway oil prices. The only potential for a real fall in oil demand is through intense economic recession triggered by massive rises in interest rates in the OECD countries." There are few written or objective dissensions to this viewpoint in the literature and it appears that the USA Department of Energy is, for the first time, acknowledging the imminence of peak oil (Johnson *et al*. 2004). The arguments appear convincing that there is a fast emerging world oil shortfall. This, together with increasing dependence on Russian and Saudi Arabia to meet the extra demand, is predicted to result in inflated oil prices. The lack of available technology to replace fluid fuel will necessitate a transition to lower energy use, greater energy efficiency and conservation, renewable fuel technology and a restructuring of society. Agriculture in general and food production and distribution in particular will be considerably handicapped and will require a total rethink, particularly industrial agriculture, which will have to move gradually towards more sustainable practices such as permaculture.

Expensive oil and world food production

The world price of oil is predicted to rise because of a number of factors including the decline in oil production, the increasing monopoly of the oil markets, increasing demand for oil as countries develop and populations grow. High yields of grain depend heavily on fuel inputs (see Table 2), and in future, competition for grain for food, feed and feedstock should induce a steep rise in the price of grain.

Oil economics are dominated by the USA, the economy of which is built around extensive transport systems, which are primarily fuelled by petroleum. Industrial agriculture is dependent on petroleum to power machinery and pumps for irrigation and to manufacture the fertilisers and herbicides on which high crop yields depend. The USA has the highest per capita consumption of gasoline and an extremely high use of gasoline per unit of food production. It also produces the highest proportion of the world's traded food and, as the world's largest importer of oil, has to manage fuel supplies with care. Thus, the USA is diversifying internal energy supplies (coal, shale oil and bio–fuels) and sourcing its supply from a diverse number of countries in order to guarantee supply. All developed nations are positioning themselves in a way similar to that of the USA.

The tragedy that is unfolding is that some of the oil and gas for the industrialized countries are sourced from developing countries that have a real need for capital from oil sales to fuel economic growth (often manufacturing). Discovery of oil in the least developed countries and its exploitation by external interests often have a negative impact locally and on the country generally. The poor are often the most detrimentally affected, particularly in countries with corrupt or despotic regimes (Shah 2005).

At present, these countries are depleting or have depleted the oil reserves that will be needed for development; particularly to finance food production in the future and they will ultimately need to buy fuel and food on world markets at inflated costs. The populations of the developing countries are still increasing, despite enormous annual death rates largely in Africa from hunger (10–15 million people) and disease (AIDS, 3 million; diarrhoea, 1.8 million; TB, 1.6 million; malaria, 1.3 million; measles, 1million) (United Nations, Millennium Indicators Database, 2004). The end of oil signals an increased problem for nations and organisations dealing with these aspects of poverty.

Any change in resource use in the USA has major implications for the rest of the world. The USA accounts for 31% of global income, and the second to fifth highest gross national incomes (Japan, Germany, UK, France) together with the USA account for 60%. The implication is that what happens to fuel supply, demand and use in the USA and its flow on to the cost of food production, will have major effects on the rate and pattern of production and consumption in the rest of the world, particularly in developing countries. The dependency of the USA on external sources of oil means that its foreign policies are influenced at all times by oil politics. It also means that oil security may take precedence over any food supply surplus to USA needs, especially those foods that are exported.

The USA uses close to 20 million barrels of oil per day and the ultimate world peak production of all liquid fuels is estimated to be close to 90 million barrels per day. There are some 200 million vehicles in the USA, about a third of the total in the world (630 million). Ivanhoe (2002) emphasised the impending problems associated with oil price increases by highlighting the dependency of urban dwellers on the two–week turn over of food and fuel in major cities. The USA consumption of petroleum products in 1998 is shown in Table 3, and emphasises that the greatest demand for oil is for transportation, which is closely associated with the extent of urbanisation.

Table 3 Oil resource use by the USA (Ivanhoe 2002).

Sector	Million barrels per day consumption
Transportation	11.68
Industrial Feed Stock	4.61
Residential and Commercial	1.13
Electric Utilities	0.29
Total	17.70

Food, feed and feedstock for industry

A consequence of scarce and expensive oil is the increasing development of fuel alcohol. In the USA, alcohol production has been increased apparently to supply an oxidant to add to gasoline to reduce polluting emissions from vehicle exhausts. However, increasingly, alcohol is being targeted as a petroleum extender. Production of alcohol in various countries is shown in Figure 4. Alcohol is produced by the fermentation of sugar, which is usually derived from maize and sugar cane that, in turn, are produced with considerable outlay of fossil fuels. The proponents of fuel alcohol production justify the industry largely on the basis of the reduced air pollution in cities (and reduced health costs) and the value of the fermentation by–products (Shapouri *et al.* 1995). Patzec (2004) has recently demonstrated that the present manufacturing process in the USA produces 2.13 billion gallons (USA) per year but more fossil fuel energy is used to produce ethanol from corn than the ethanol's calorific value. Alcohol production from sugar cane yields more energy in alcohol than is used in production as long as the bagasse is also transformed into an exportable energy source (Pimentel, 2001).

The energy balance of the conversion of maize or sugar cane to alcohol does not take into account the costs of transporting alcohol from distant fields to the major cities with air pollution problems (quantities produced are too low to justify the establishment of pipe lines). Also not factored in is the building infrastructure required to store alcohol, high costs of soil erosion associated with grain production, depletion of resources such as water and the down–stream effects of pollution caused by run–off of nutrients from farms. For example, no costs are directed at USA grain producers for the 21,000 square mile 'Dead Zone' in the Gulf of Mexico caused by eutrophication and attributable, to a considerable extent, to fertilizer run–off via the Mississippi basin from grain lands. Nor does it include the loss of land mass in the same area attributable to both subsidence from oil removal and the low flows of water and sediment in the Mississippi river with the huge off–take of water for irrigation

Alcohol production will undoubtedly provide alternative markets for grain and much of the 'set–aside land' in industrialized countries will be used for this purpose. It is estimated that 12% of the maize production in the United States will be diverted from animal and human food/feed to alcohol production. This will surely 'dry up' world surplus grain and challenge the world's chances of avoiding mass starvation if food shortages occur in the developing nations, particularly in Africa. Many countries are now actively encouraging the development of fuel ethanol industries (Berg 2001).

It appears inevitable that grain prices will increase throughout the world. Inexpensive grain will become scarce in a world where large numbers of resource–poor people already suffer under nutrition and malnutrition. As the competition for grain for food, feed or feedstock intensifies, it is likely that the price of many of the inputs to grain farming will increase as fuel

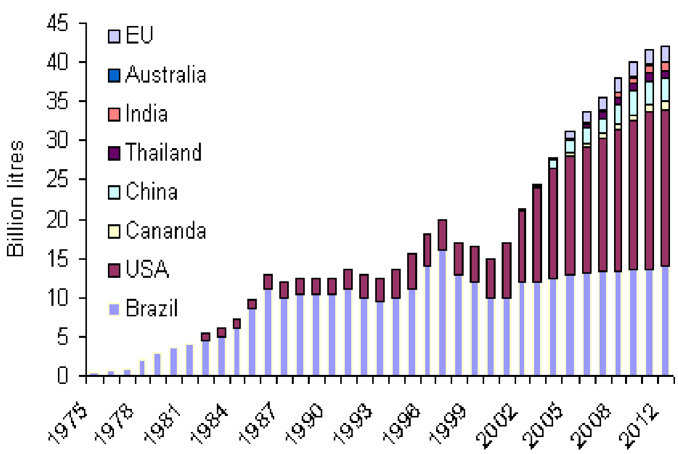

Figure 4 Global tendencies in the production of alcohol (Berg 2003).

prices increase. Inevitably, North American and European subsidies on grain production (which are as high as 28% of the cost of production) will be removed. The higher costs of inputs, lowered subsidies and competition for end use, together with the potential for the environmental costs to be added to the cost of grain production, will ensure that the world price will be high and availability for feeding animals will be reduced.

If grain is to meet the proposed increase in industrialized pig and poultry industries foreseen in the Livestock Revolution (Delgado *et al.* 1999), it will have to compete with the ever–increasing demand for feedstock. Much of the set aside land in Europe and America may have to be brought back into production to meet the demand for feedstock for bio–fuel production, but in the developing countries, there is no such land available other than those in marginal areas and in rain forests. In 2000, 3.9 million hectares of agricultural land in the European Union, on which feedstock for alcohol and bio fuel could be grown, was set aside. These areas could produce 1.2–5% of total transport fuel consumption (Gunter Hanrerich 2002, see FO Lights 2002). This suggests that the bio–fuel production from set aside land will have only a minor impact on fuel availability when oil becomes scarce and prices rise.

Bio–fuels such as oil from vegetable oil seed, coconuts or oil palm have only limited application to transport energy because of the magnitude of the requirements, because they are produced with inputs of fossil fuels and because land use for oil crops will compete with land use for food crops.

Despite the obvious problems, it is apparent that many countries, especially the USA, are pursuing the alcohol option; there is mounting interest in bio–fuels all over the world. On small farms in developing countries, there are options to use producer gas generated from crop by–products (Preston and Leng 2004).

It is estimated that by 2010, some 50 million tonnes of grain will be converted to alcohol in the USA (Figure 5). This is close to the present exportable grain surplus (about 60 million tonnes) from that country. The related problem is that, as is the case with oil, world demand exceeds supply (Figure 6), with the result that

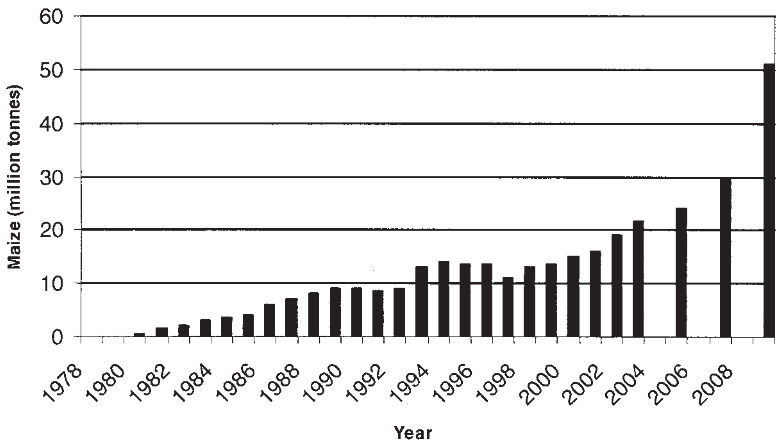

Figure 5 Past and future trends for the conversion of maize to alcohol in the USA (Pearse Lyons and Bannerman 2001).

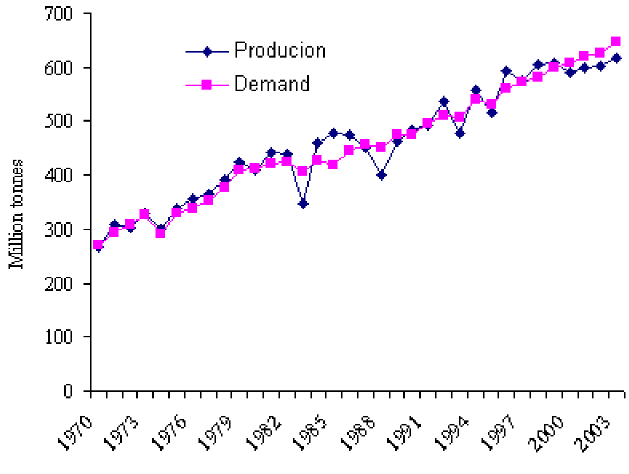

Figure 6 World production of and demand for maize (Rameker 2004).

world stocks have steadily declined over the past few years (Figure 7) and production per capita is in decline (see Figure 8). The same trend is seen for China, a country whose high rate of economic growth is fuelling the demand for grain as well as for oil. However, demand over the past four years has increasingly exceeded production with the result that the shortfall has had to be made up from reserve stocks. It is expected that China will be a net importer of maize in 2005 (Rameker 2004). Current world grain stocks are the lowest for 30 years (Brown 2004). Thus the future for feed grains (the future for soybeans is similar) (Rameker 2004) is likely to mirror that for oil, with a steadily increasing gap between supply and demand, and therefore increasing prices. The repercussions on the intensive animal feed industries are likely to be dramatic and contrary to the optimistic predictions of the International Food Policy Research Institute, Washington DC (Delgado *et al.* 1999).

The future role of ruminants in meat production

As the energy crisis evolves, it is likely that specialised agriculture systems providing single commodities to extensive markets will gradually be displaced by mixed and integrated crop and animal farming, guided by modern permaculture principles and targeted for local consumption. Many rural communities in the industrialised world will need to be reinforced at the expense of suburban development as their roles in local food production increase. The shift from industrialised farming to sustainable agriculture in Cuba following the loss of cheap oil from the former Soviet Union in 1989 may be an example of the strategy that will evolve in the developed countries (Funes *et al.* 2002). In the developing countries, small, integrated farming systems appear to offer the greatest scope to maintain food production (UTA Foundation 2005).

Ruminant production from dispersed production systems in rural settings and based on roughage and agro–industrial by–products appears to hold a major hope for meeting the demand for large quantities of medium to high quality protein for human consumption at affordable prices (Leng 2002; Leng 2004). When petroleum became relatively expensive in Cuba after the former Soviet Union withdrew their subsidised oil, industrialised pig and poultry production virtually ceased overnight and people returned to traditional methods of feeding using local resources.

A strategy that produces grain and protein crops at the expense of both the non–replaceable resources (soil and water) and the endowment of non–renewable resources (fossil fuels) will be at immense cost to future world populations. However, in the short term it is

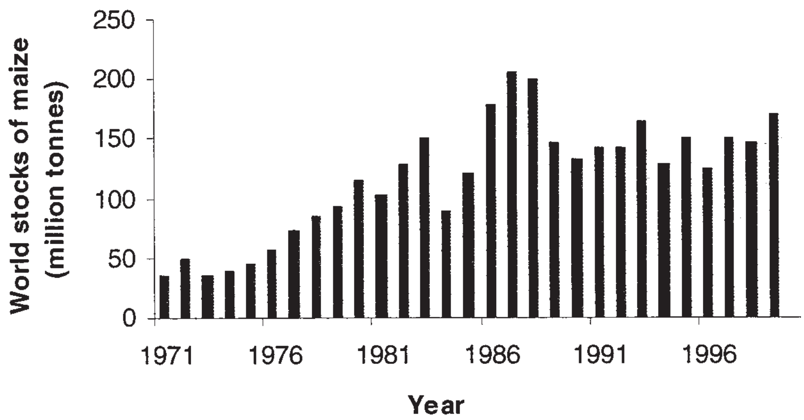

Figure 7 Trends in world stocks of maize (Rameker 2004).

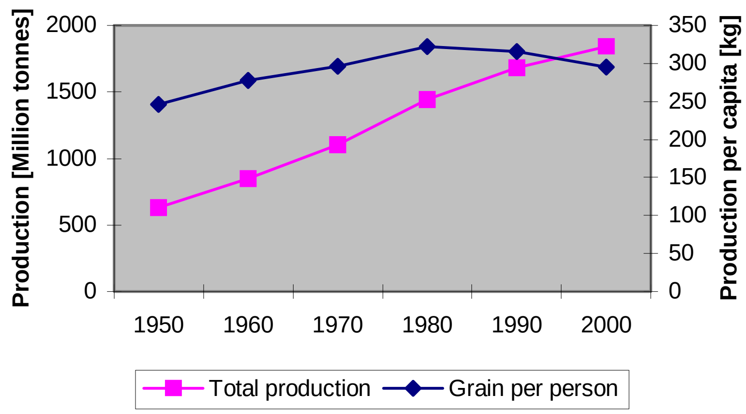

Figure 8 The decreasing world per capita grain availability (Brown and Kane 1994).

inevitable that food will increase in price and the use of grain for animal production will force up the price of meat and milk.

It is imperative that, world wide, the decline in oil– and water resources and in soil fertility must be slowed and, where possible, stopped. Global warming must be also be reduced. Industrial animal production systems cannot be sustained in the future and alternative sources of protein or meat/milk must be emphasised. Poultry and pigs can be produced without grain–based feeds, but the ruminant animal has the greatest potential for sustaining meat and milk production.

Herbivorous animals do not (or should not) compete for resources with humans. For a range of reasons, major meat–industries based on grain are established in every country in the world. At present, more than a third of the world's grain production is destined for feeding to animals. The grain–fed ruminant, in general, produces at low efficiencies relative to monogastric animals. Nevertheless, the practice of finishing cattle in grain–based feedlots dominates ruminant meat production in most industrialised countries. A recent article estimated that when all costs are taken into consideration, each kg of liveweight gain of feedlot cattle required the burning of approximately 5.7 litres of oil (Appenzeller, 2004).

A large amount of research has demonstrated that considerable improvement in production can be achieved in the forage fed ruminant by applying known scientific principles. It is possible to use poor quality roughages and agro–industrial by–products as feeds and achieve highly efficient production (Leng 1990; Leng, 2004).

With 1.34 billion cattle and buffalo and 1.68 billion small ruminants (sheep and goats) already on the planet, the animal resources to produce the meat and milk needed for future generations are already available. If the annual meat off–takes were 100 kg per per cow and 10 kg per head for small ruminants, the world production of meat would be 151 billion kg or 25 kg/head of population per year from this resource alone. The fallacies in such calculations are recognised and the figures are quoted here only because they indicate the huge potential of ruminants to provide meat/protein for humans. Except for minor production from a number of other herbivores (horse, sheep, goats, llama, yaks and camels), cattle already supply the majority of the world's milk and there are no likely contenders for this role from monogastric animals.

The issue of whether to promote industrial pig and poultry development or to rely on ruminants for future animal protein is critical to huge areas of resource use in the world and commitment to the wrong animal may have devastating effects on resource availability for the poorest of nations as the decline in oil starts to take effect.

The population of the developed world is predicted to decrease in size whereas 3 billion people are likely to be born in developing countries in the next 20 years. It is their health and well–being that will be at stake when food production is compromised by the consequences of peak oil.

Conclusion

It is appropriate to conclude with a number of quotes from distinguished petroleum scientists:

- Campbell (2001), in discussing the decline in oil, wrote, "All this is incredibly obvious (the decline in oil and its effects on the price of world oil). The inexplicable part is our great reluctance to look reality in the face and at least make some plans for what promises to be one of the greatest economic and political discontinuities of all time."
- Youngquist (1997), in discussing future share of resources in the world, wrote, "If China used oil on a per capita basis at the same rate as the United States, the Chinese alone would use approximately 81 million barrels of oil a day, which is 10 million barrels more than the entire present world oil production. The pleasant 'Petroleum Interval' will also bypass most of the more than three quarters of a billion people (now 1 billion) in India, as well as many people in Africa and South America. These 'oil–less' people will only get a passing distant glimpse of the benefits which oil bestows on the fortunate people who have substantial access to it and it could be added, people who use it with conspicuous lack of restraint."

As the 100 years of growth ends, peak oil represents a turning point for humankind (growth in GDP and growth in energy use are highly related). Populations in developing countries will also peak as resources limit the generation of food and facilities. The period during which oil reserves decline will be a period of high tension with great potential for dominance by those industrial nations with the most to lose (Ruppert 2004). Priorities must shift from conspicuous resource exploitation to self–sufficiency and sustainability of food production and the environment.

The greatest issue in the world appears to be how to use oil efficiently from now on. The first step would be to reduce the flagrant and conspicuous use of oil in transportation. The second, to enact policies to remove incentives for urbanisation of rural people and de–urbanise the cities and make the rural settings more attractive to bring people back into agriculture as the decline of oil starts to have its effects. The search must continue for new, renewable energy sources. Harnessing solar energy appears to be the most logical, but it is not easy to substitute the requirement of the world for liquid fuel with solar generated power. Recent developments of alternative renewable fuels will all contribute to meeting energy requirements. Harnessing these energy sources seems to be potentially possible with new technology such as the use of silicon generated from sand using dispersed energy capture technology (Auer 2004). However, the problem remains that just to replace the oil–using vehicles in the UK with vehicles running on hydrogen alone would require the construction of 100 nuclear plants or 100 000 wind turbines (Oswald and Oswald 2004). There is no cheap fix for the energy of the future.

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