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LIVESTOCK IN SUSTAINABLE RURAL DEVELOPMENT

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In recent years fuelled by low cost of fossil fuel, high labour cost and high capital cost there has been a tendency to underutilise both renewable and fossil energy sources. This has been particularly so in market oriented countries where cost of labour and labour efficiency, so to speak, became substituted for efficient resource utilisation.

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The high cost of capital and labour led to specialization in agriculture which had many undesirable consequences from the point of view of sustainability. Specialized crop farms appeared on the best land. Price support for cereals and cheap fertilizer led to increased yield of grain so that a secure profit could be maintained with only crops and paying attention only to the main product. It was no longer profitable or necessary to keep livestock to utilize crop residues such as straw and other by-products. Crop residues became waste products and created pollution problems. They were disposed of by burning which has now been forbidden in most countries. It is now substituted by a more environment friendly slow burning by chopping and burying it. In order to maintain high profit, small farms became amalgamated into large farms. Labour gave way to fossil energy-driven machines which became larger as farms became larger. From a sociological point of view this led to rural depletion which was tolerated since the industrial towns in industrialised countries could absorb the labour made redundant from the countryside. From the point of view of animals, similar consequences became apparent. Farmers became specialised dairy farmers, beef farmers and to some extent sheep farmers. Pigs and poultry production became industrialised altogether and completely separated from land.

Due to high labour and capital cost and for the post-war desire for self-sufficiency, cattle were selected for high yield, beef cattle for high growth rate etc. They were also selected for homogeniety, particularly for dairy cattle, pigs and poultry. With the help of artificial insemination superior males could be used to sire many females and more recently, with use of embryo transfer, superior females can be used to a far greater extent (Orskov & Viglizzo 1994). Homogeneous and high yielding cattle were more profitable as profitability could be predicted with greater accuracy. Machines are installed which can now almost perform all functions of feeding and milking. Herds have become larger, and due to large amounts of bought in feed also dairy farms have become less dependent on the acreage of land. The results of this development has been that manure has become a pollutant. Disposal of slurry on the small area of land gives rise to constant problems of pollution of rivers and waterways. Presently some legislation has been introduced to give some control. Dairy cattle have become sensitive to metabolic disorders during stress any conditions leading to off feed tend to give rise to acetonaemia. In order to achieve milk yield of 40 to 50 kg/d of 600 kg cows, the consumption of feed at about 3 to 4 times maintenance could only be achieved at a high fermentation rate i.e. with high quality feed, such as young grass either grazed or preserved as hay or silage and grain and high quality by-products such as sugar beet, pulp, brewers grain or maize gluters and protein supplements such as soyabean meal, fish meal etc. Crop residues such as straw can hardly be used at all. In effect the yield potential of the animals far exceeded the feed potential of the natural resource base.

The industrialisation of pig and poultry production has also led to many undesirable environmental consequences, particularly related to disposal of manure as these farms have become separated from land. Some of the manure, for instance pig manure from pigs supplemented with copper caused problems of toxification of land and caused copper toxicity in sheep grazing land fertilised by such pig manure.

Crop and animal agriculture in so-called industrialised countries face enormous problems. It is a non-sustainable system. In fact the energy contained in processed food at the supermarket is several times less than the fossil fuel used in cultivating the land, sowing the seeds, fertiliser, herbicides and pesticides, harvesting and processing and transport.

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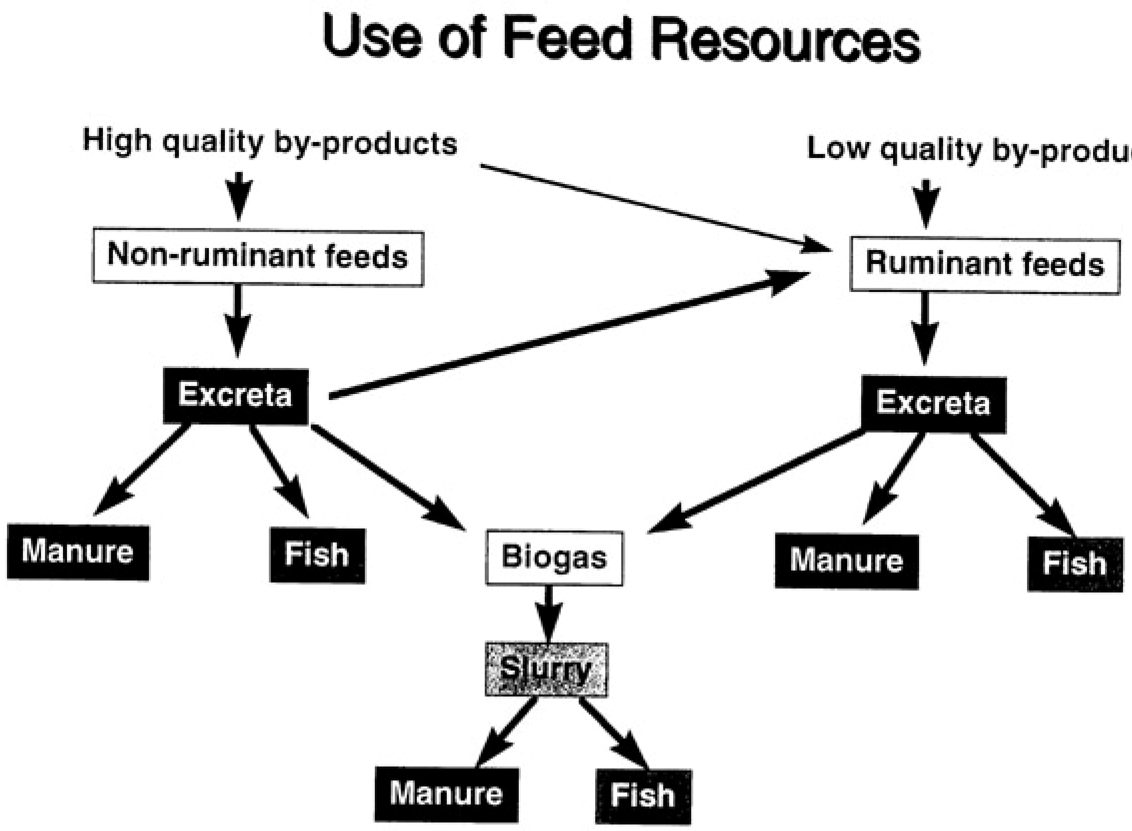
In contrast to industralised countries in less developed or less industrialised countries crops and livestock are normally integrated as indeed crop and livestock used to be, before the second world war in Europe. These systems are also intact in countries like Poland and parts of the former Yugoslavia which were not to any large extent collectivised as in other centrally planned economies.

There is a conflict. Developing countries with small labour intensive crop livestock farms feel driven to increase farm size to increase labour efficiency. However, in many countries "labour saving" industrial technologies have reduced the requirement for labour in industries. In many countries notably Latin America this has led to acute urban poverty. The rural poor have left for the cities where in many instances there has been no work.

In the following I will try to suggest some alternatives that may assist in alleviating rural poverty through increasing feed resource efficiencies.

Feed resource efficiency

In industrialised countries feed efficiency is often expressed as kg feed/kg gain or kg milk and more sophisticated metabolisable energy/unit of product. The next step in resource use was never considered except in a negative manner. There is, however, immense possibilities of increasing the efficiency of renewable resources. In Fig. 1, I have illustrated the possibilities, some of which are already utilised by small scale farmers.



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In crop livestock areas let us consider that crop residues constitute the main feed for animals. In most areas, there are invariably also areas for some grazing or cut and carry feeds e.g. edges of roads and fields, branches and leaves and during seasons in which the major crops are not grown e.g. berseen clover in cold seasons between rice crops. Let us consider that there are high quality crop residues, which are destined for animals e.g. brans, brewers grains, tofu waste. While these products can also be used as supplements for ruminants, they can be utilised by non-ruminants which are always more efficient as at least the soluble parts or non-cellulosic parts can be utilised without losses in methane production; which should also appeal to environmentalists. The excreta from monogastric animals (Fig. 1) can, however, be an excellent supplement for ruminants. Poultry manure contain an excess of N which in turn can support low quality crop residues which are often low in N e.g. straw. This is brilliantly illustrated by Kikuyo farmers in Kenya who feed all the poultry manure as a supplement to cows otherwise fed on maize stover and Napier grass. Here one can envisage an evaluation of poultry fed not only in the efficiency for egg or broiler production but also to provide the best supplement for cattle. The low quality or high cellulosic feeds e.g. straw, stalks and stovers will generally have to be fed to ruminants. The excreta from ruminants can be used for different purposes depending on the area. In the humid tropics such as Vietnam and South China excreta is used for small scale production of biogas often with use of simple and cheap polyvinyl tubes (Sarwatt et al., 1995). The biogas slurry high in microbial protein is used to fertilize fish ponds and the solids as manure. Here the feeding and feed regime may consider also the resource use for biogas and fish. It is certain that many additives e.g. copper in pig diets would soon be eliminated as this virtually makes the excreta poisonous. In other areas excreta can be used directly to fertilise fish ponds or for that matter production of earthworms to feed as a protein supplement for monogastric animals. Such use of resources is sustainable, but also labour intensive. The use of biogas can indeed help also to prevent deforestation. In many densely populated areas in the tropics women spend a long time colecting firewood. The use of biogas in areas of intensive animal production where there is an excess of excreta can make the pollution problems much less intense. In some villages in the Philippines and China the pollution problems created by pig manure could be greatly reduced by using biogas to remove the organic matter except the lignin or humus.

Supplementation

The value of supplements brought into farms as mentioned before is generally judged directly on the effect of animal performance. Results from a trial carried out in Sri Lanka illustrates well how supplementation can have consequences both for plant, soils and animals. In this trial carried out by Pathirana & Orskov (1996), cattle at a high stocking rate was grazing under coconut trees. Though animal performance was low due to low level nutrition as the calving rate was only 0.22 but there was clearly an effect on coconut yield and soil water holding capacity as the biomas growth under the coconut was turned over rapidly. The effect of offering the cattle supplement of rice straw and still more so with rice bran supplementation influenced both animal performance coconut yield and soil fertility. There are no doubt many instances of similar observations, thus supplementing grazing animals has an effect also on grassland productivity and soil which is often not taken into account and which is often more viable and perhaps sustainable than bringing in artificial fertiliser. The price of supplements should therefore also be affected by the quantity and quality of the subsequent resource. It would in many instances at least lead to care in overfeeding of items which destroyed the following resource e.g. copper in pig diets as discussed earlier.

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Table 1. Effect on yield of coconut, soil water holding capacity and number of calves born

	Nuts/palm year	Copra/palm year	Water holding capacity	Calves/year
Non grazing	41.1	11.1	16.9	
Grazing	47.9	13.3	18.3	0.22
Grazing + rice straw	50.6	14.2	18.9	0.50
Grazing + rice straw + supplements	57.4	16.7	17.6	0.89

Upgrading of crop residues

As for supplementation, methods of upgrading should also take into account the benefit or damage to the following resource. The most practical methods of upgrading used on farms presently is either caustic soda or ammonia as alkali. Ammonia can be applied both as gaseous ammonia, ammonium hydroxide or as urea which on hydrolysis yield ammonia. While use of ammonia also affect excretion of N in manure and urine this may have a positive effect on the manure as a resource. It is very unlikely that sodium would have any benefit, in many instances it would have a negative effect on soil structure.

Selection of crops for total resource utilisation

With the pressure on self-sufficiency in food following the second world war, plant breeders everywhere looked for the main product e.g. grain or seeds, while little attention was given to crop residues except to prevent the crops from lodging. It is quite remarkable that so little attention has been given to selection for better crop residues. Research with both barley, wheat, rice and oat straw (Tuah *et al*. 1984, Vadevaloo 1992) have shown substantial differences in nutritive value between varieties without any relationship to yield of grain. It is of course possible that a higher nutritive value of crop residues may not always give the best quality of the next resource i.e. the excreta. Obviously the quantity will be reduced.

Crop residues as industrial raw material and livestock food

While grain can be used as an industrial raw material for production of starch, sugar, alcohol, plastic etc. by far the bulk of grain will in most countries be for humans and monogastric animals. The challenge is in use of crop residues as industrial raw material (Orskov, 1991).

Botanical separation into stem, leaves, chaff and nodes

Stems. In general the largest proportion of crop residues consist of stems e.g. 50 to 60%. Stems are similar to wood in chemical composition and can effectively be used as raw material for paper pulp and for hardboard to replace wood for that purpose. The stems are low in nutritive value and in general small ruminants given a choice will eat the leafy part and reject stems.

Leaf. Leaf is a poor material for paper and hardboard making but excellent feed for animals. The proportion varies from about 30 to 45% of the weight of the straw. Leaf has generally a nutritive value similar to high quality hay. Leaf is also maleable to enzyme treatment so that a large portion of the cellulosic and hemicellulosic materials can be solubilised making it a possible feed for monogastric animals as well.

Chaff and nodes constitute smaller proportion each from 5 to 10% of weight. These products are perhaps best pressed into briguettes and used as fuel but can also be used as ruminant feed. The nutritive value is generally between stem and leaf.

Separation by physiochemical treatment

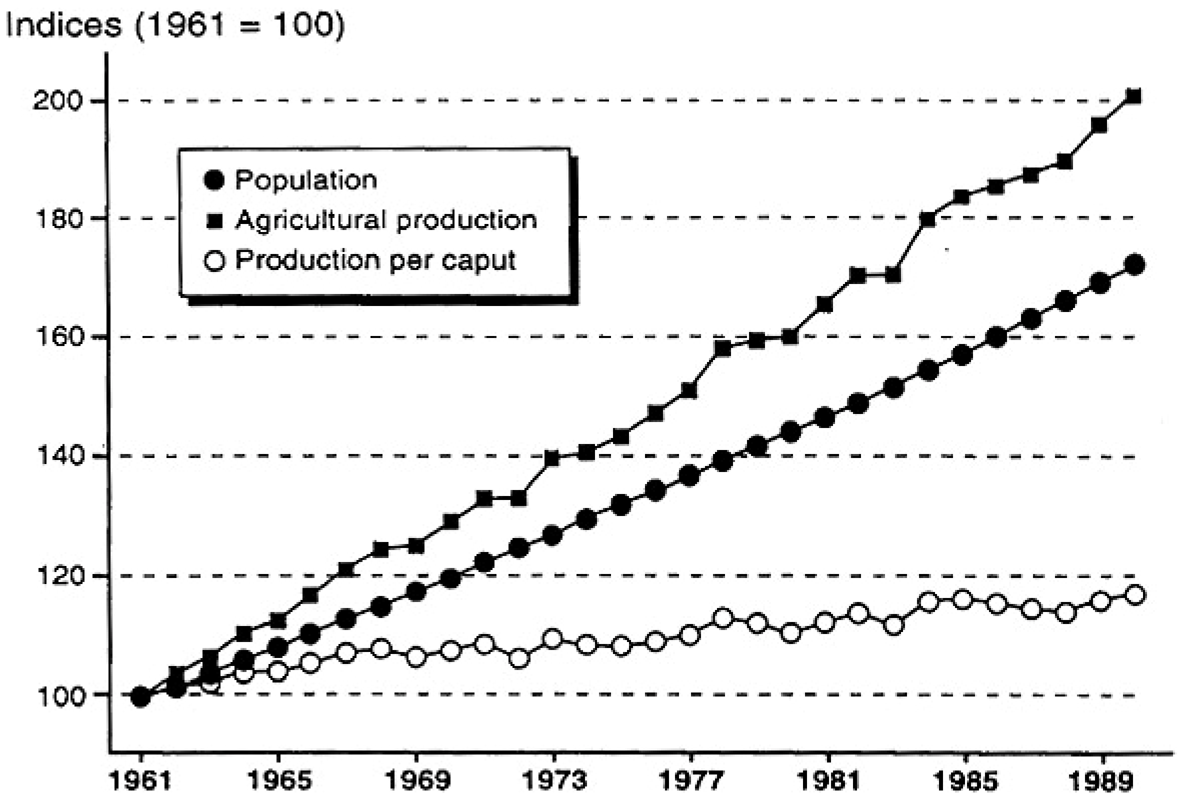
In recent years steam treatment has been developed particularly for separation of bagasse into constituent fractions of hemicellulose, cellulose and lignin. There are several possibilities. Mild steam treatment with some hydrolysis of hemicellulose and dissruption of bonds between lignin and hemicellulose given a substantial increase in nutritive value. Thus burning some straw to generate steam can effectively increase the nutritive value of the rest. This treatment can equally well be used for cereal straw. The steam treated materials can be improved further by enzyme treatment so that monogastric animals can utilise them. Steam treatment at higher pressure can give rice to production of antinutritive constituents e.g. furfural and phenolics from lignin degradation. A more harsh treatment of lignocellulosic crop residues can separate the fraction to hemicellulose, cellulose and lignin. Hemicellulose syrup can be used as animal feed or fermented to yield alcohol, cellulose can be used for paper making and lignin produced by this method can have many industrial uses e.g. plastic, glue, paint, road material and many others.

There are numerous possibilities with which to utilise resources better, both in non-industrial and industrial countries. Crops have to be seen in a holistic way and the most appropriate utilisation of each component encouraged. This will vary with climate, socioeconomic conditions, level of industrialisation and many other aspects. Livestock both ruminants and non-ruminants have a part to play in this process. The process will be more labour consuming than the present system in which only part of the resources are used due to so-called labour efficiency.

It is interesting here that China which has 7% of the world's arable land feeds 22% of the world's population. Even so while China is probably one of the most resource conscious people in the world, they still waste enormous quantities of feed resources. A large proportion of low quality crop residues are not used. Poultry and pig manure is generally not used for feeding to ruminants.

Better use of resources, in particular, renewable resources in the future will no doubt decrease rural poverty but will have to be encouraged by appropriate taxation systems and appropriate research etc. It will give a new dimension to plant and animal breeding as many more aspects of crops will have to be considered. Also for animals and animal production, systems will have to be matched to the part they have to play in the course of resource utilisation from photosynthetic biomas to mineralisation.

The world population is increasing and so far food production is on the whole matching, though some countries have large deficits (see Fig. 2 and from FAO 1993). The question many people ask is, "Can the increase be sustained, and what has been driving the increase in food production?" There is no doubt that an increase in fossil fuel consumption has in part been responsible but plant breeders have produced superior varieties. Fossil fuel driven machines have perhaps also improved the total area for cultivation and perhaps also improved cultivation methods. However, it is probably much more likely that cheap fossil fuel has enabled a production of relatively cheap fertiliser, particularly nitrogenous fertiliser which has to a large extent been responsible for the increased yield e.g. green revolution in India. It is a question to what extent a further increase in agricultural production can be driven by a still greater increase in use of fertiliser produced from fossil derived energy. Many will argue that it cannot.



Reproduced from: FAO (1993), *Agriculture towards* 2010, Rome

While a further increase in fossil energy consumption is almost inevitable as several Asian countries are becoming more industrialised, they have a long way to catch up, however. The USA with less than 5% of the world's population contribute 29% to greenhouse gasses. China with 22% of the population produce only 4%. The environmental consequences will be enormous and we must plan to reduce fossil oil consumption and increase the efficiency with which renewable resources are used. It is fortunate, however, that there are so many possibilities, some of which have been outlined before. It will no doubt be more labour consuming than using lots of fossil fuel at the expense of underutilising renewable resources. Labour is expensive to a large extent because this forms the basis for taxation. In the future no doubt, efficient use of resources will become much more prominant rather than encouraging further use of fossil energy.

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I believe that the aspects mentioned will also have a bearing on how feeds are to be evaluated in the future and how best to exploit our animals in their role in the systems of efficient resource utilisation. We need to understand much better how to use both monogastric and ruminants in a holistic interaction with plants and soil. The sciences are no less challenging. Can a cow achieve yields of 20-30 kg milk/day on diets based on straw which will be a sustainable system. Many animals have been bred away from their natural resource base. Concentrated efforts by plants and animal scientists can, I believe, make it possible.

Efficient use of low quality resources will mean smaller farms as the resources cannot be transported over large distances, again favouring smaller farm and rural employment. Countries like Poland with their small farms intact can provide a model. Large scale industrial farms are not sustainable. They can only survive in artificial structures supported by rich urban industrial sectors. They require large fossil fuel inputs, they lead to inefficient feed resource utilisation with a large part of the resources causing problems of pollution.

Progress in genetic engineering need to be led by goals relating to feed resource efficiency. Equally plant breeding needs to be geared to how best to utilise the whole resource base. This is the challenge for scientists in the next century. Failure to do so can have disastrous consequences.

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