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CASE STUDY OF THE LIVESTOCK SECTOR

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Preface

NRMP-IEA Technological Scenarios

The Natural Resources Management Project (NRMP) assisted by USAID in association with the Institute for Economic Analysis (IEA) at New York University is carrying out a modelling exercise to project the economic, employment and environmental consequences of different development paths for the Indonesian economy. The purpose is to provide advice to the Indonesian National Planning Agency (BAPPENAS) to assist in the development of the next five-year plan (Repelita VI) and the next Long-Term Development Plan. The first stage of this work has already been completed with the support of the Environmental Programming Support Services Project of CIDA.

The analysis, of which the present paper is a component, will provide advice on the trade-offs and complementarities between the growth of income and employment on the one hand, and the levels of natural resource depletion and degradation of the natural environment on the other. For instance, it is important for policy makers to know how the development of the pulp and cement industries over the next 20 years is likely to affect air and water pollution and how costly or cost-saving it will be to adopt cleaner technologies than are being used now.

The analytical framework includes a dynamic input-output model covering all economic activities. The model is dynamic in two senses. First, it incorporates a representation of investment in which levels of sectoral investment depend on expected growth of output, the technology in use and levels of capacity utilisation. Secondly, the model is dynamic in that it explicitly incorporates projections of changes in technology for a range of sectors in the economy, including agricultural sectors, forestry, energy sectors and key manufacturing sectors.

Technological scenarios are developed for each of these sectors using detailed information about likely technological and institutional changes obtained from technical experts. They include expected changes in intermediate inputs, notably energy and raw materials, capital stocks and human resources of different skill types as well as expected changes in natural resource usage and environmental degradation associated with current and alternative future technologies.

This paper is one of a series of working papers prepared by NRMP and IEA researchers in collaboration with industry experts. The papers will form a vital part of the data base for the numerical computations. In addition, they will be valuable as stand-alone analyses of technological futures for a range of important industries in Indonesia.

It should be noted, however, that some of these working papers (especially those on manufacturing sectors) were prepared under severe time limits and should not be taken to represent the last word on technological change in the industries in question.

BEST AVAILABLE DOCUMENT

I Introduction

This case study covers the production of livestock and poultry products, including milk and eggs (Sector 4 in the NRMP-IEA 30 sector classification); it does not include the processing of livestock or livestock products.

The traditional (i.e. pre-1970) methods of livestock production and the relatively small amount of livestock products (meat and eggs) consumed per capita, meant that the land, labour and manufactured goods requirements of this sector were relatively insignificant. In addition, the majority of production was for own-consumption, and commercial production for urban markets represented a minor part of total production.

Under traditional conditions animal products were by-products of a range of other farm activities, making use of otherwise unused resources from local food processing and the local environment. In addition, livestock manure, especially from cattle, was (and is) essential for maintaining soil fertility for dryland agriculture; cattle and duck manure contributed to ricefield fertility; and pig and chicken manure helped maintain housegarden soil fertility.

Cattle and buffalo were grazed on such local land as was available and farmers hand-cut grass for stall-feeding at night; ex-draft animals were slaughtered for meat. Dairy cattle were almost non-existent, and cow's milk was not a normal part of the diet. Pork production, in areas where eating pork was acceptable, was a household affair using local feedstuffs (banana trunks, rice bran and leafy greens). Poultry production (chickens and ducks) was extensive with a diet from scavenging supplemented with rice bran, maize and cassava. Goat production was extensive, commonly with tethered grazing.

Until the late-1970s production of meat and livestock products was generally a non-specialised farming activity operating in parallel with the production of other food crops. The early-1980s saw the appearance of small-scale battery production, using low technology (bamboo cages) for production of poultry (eggs and broilers), importation of dairy cattle (mainly from Australia) and the beginnings of specialised beef production (fattening in feedlots). Since the late-1980s, low-technology chicken egg and meat production has declined in importance due to competition from intensive production methods. The rapid expansion of production during the 1980s has utilised up-to-date production methods imported from industrial countries, resulting in a parallel rise of large-scale stockfeed importation, milling and formulation enterprises.

It should be noted that within this sector a 'dual economy' operates: the traditional sector, with extensive production largely for own-consumption, and the rapidly expanding modern, intensive sector which is highly capital intensive and wholly commercial in orientation. These two modes of production have almost no interaction at the level of production technology, except for the use of some processed stockfeed by small-scale farmers. There is also little

complementarity in the market place, with traditional producers supplying their own needs and those of adjacent rural communities, and modern intensive producers focused on supplying the urban domestic, restaurant and fast-food markets. Traditional production is undergoing relatively slow technical change, while intensive production is keen to use the most 'advanced' methods available. It is also clear that traditional production methods are not going to disappear, as they make good use of otherwise unused local resources, help maintain soil fertility and provide a source of income and a savings bank 'on the hoof' that can be tapped in times of financial need. Thus, changes in average technological coefficients for the sector disguise a widening gulf between traditional and modern livestock production.

According to government data, total meat production in 1985 was 808 thousand tonnes, by 1990 it had risen to 1,027 thousand tonnes. During the 1985-90 period, production of non-poultry meat (beef, buffalo, goat, sheep, pork and horse) increased at only 1.13% p.a., and its share in estimated total meat consumption declined from 61% to 50%; its share is projected to decline further in coming years. However, there has been a slow increase in the proportion of beef produced (fattened) in feedlots, mainly to meet the demand for higher quality meat by the wealthier segment of the (urban) population.

The most significant change in the last 20 years has been the rapid growth of intensive poultry production, both for eggs and meat. Intensive (battery) production of chicken eggs and meat began in the early 1980s, and over 1985-90 grew at an annual rate averaging 19%; by 1990 it accounted for over half total poultry meat production (311,000 of 509,000 tonnes). From about the same time, production of hen's eggs (increasingly from modern battery production) and cow's milk has increased rapidly, growing at 5.5% and 12.0% p.a. respectively between 1985 and 1990. These two products alone accounted for almost half the available animal products in 1990.

As a consequence of the rapid increase in intensive poultry production (meat and eggs) and milk, per capita consumption of animal products (meat, milk and eggs) increased at an average rate of 4.34% p.a. over 1985-90, growing from 8.3 kg to 10.3 kg per capita/annum (Dit.Jen. Perternakan 1992).

According to the World Bank (1992), as incomes increase there will be a rapidly rising demand for animal products in the years to 2010, with an increasing proportion supplied from intensive poultry and dairy production. Industry experts (and the World Bank) anticipate only a relatively slow growth in total demand for beef, of which intensive, feedlot beef will make up a small but increasing proportion. Milk and eggs are expected to make up a steadily increasing proportion of output from this rapidly growing sector.

Table 1:
Production of Meat, Milk and Eggs 1985 and 1990.

	1985 x1000 t	% tot	1990 x1000 t	% tot	% chg
Beef	227.4	16.6	259.2	14.0	2.65
Buffalo	48.6	3.5	44.3	2.4	-1.84
Goat	49.5	3.6	58.3	3.1	3.33
Sheep	29.8	2.2	31.7	1.7	1.24
Pork	133.2	9.7	123.3	6.6	-1.53
Horse	1.7	0.1	1.7	0.1	0.0
Vill. Chicken	178.0	13.0	176.6	9.5	-0.15
Intens. Layer	15.8	1.2	36.3	2.0	18.08
Intens. Broiler	114.5	8.4	274.3	14.8	19.09
Ducks	9.9	0.7	21.5	1.2	16.73
Milk	191.9	14.0	345.6	18.6	12.49
Eggs	369.9	41.0	484.0	26.1	5.52
Total Meat	808.4	59.0	1,027	55.3	4.91
Total Animal Prod.	1,370.2	100.0	1,856.8	100.0	6.27

Note: Total Animal Products is the sum of meat, milk and eggs.
Source: Buku Statistic Peternakan 1991, Dit.Jen. Peternakan, 1992.

The change to intensive production methods has resulted in the rapid expansion of a specialised poultry sub-sector within the livestock sector, with large production (and processing) facilities located close to major urban centres. In addition, the demand for stockfeed has stimulated the production of maize and soybeans, and required importation of additional soymeal and other stockfeeds.

II .Intermediate Inputs

In 1985 intermediate inputs from only four sectors (livestock products (18), other food products (33), poultry and products (20) and retail and wholesale trade (62)) accounted for 83% of total intermediate inputs (Table 2). However, the livestock sector is dissimilar to the other three agricultural sectors, in that it requires inputs from almost every other sector of the economy, despite the concentration of intermediate inputs from a few sectors (see Annex 1). In this respect, it has more in common with various industrial sectors than with food and tree crop agriculture, and this similarity (intensive production in 'animal factories') is expected to increase in the future.

Table 2:
Livestock and Livestock Products, Main Intermediate Inputs -1985.

Sector Name	Sector	MRp	%
Livestock products	18	1,108,095	46.0
Other food products	33	317,967	13.2
Poultry & products	20	306,785	12.7
Retail & wholesale trade	62	270,153	11.2
Cereal mill products	30	60,600	2.5
Road transport	65	55,906	2.3
Petroleum refinery	47	33,400	1.4
Sugar cane & brown sugar	8	31,880	1.3
Chemicals	40	27,307	1.1
Financial intermediaries	70	24,700	1.0
Sub-Total Intermediate Inputs	190	2,409,781	100.0

Note: The complete table is presented in Annex 1.
Source: NRMP-IEA 75-sector I-O Model.

The proportion of intermediate inputs coming from within the sector (some 46%) is high because the NRMP-IEA 30-sector I-O model combines both livestock production and slaughtering. Of the 46% of inputs coming from within the sector, the 75-sector I-O model reveals that two thirds (66.9% or about 30% of total intermediate inputs) are accounted for by slaughtering alone. Likewise, the 75-sector model shows that the 13% of inputs from 'other food products' (#11, food, beverages and tobacco in the 30-sector model) are in fact animal stockfeed. Similarly, for the poultry sub-sector (#20 in the 75-sector I-O model), some 57% of its inputs are stockfeed, from the 'other food products' sector in the 75-sector model.

Intermediate inputs from sector #20 (poultry and products) are assumed to be the provision of breeding stock and day-old chicks within the intensive poultry sub-sector. Inputs from retail and wholesale trade (#62) are assumed to be services provided to producers, particularly intensive livestock producers.

Labour Requirements

Available data on labour use in intensive livestock production is fragmentary. Because of the extensive nature of (semi-) traditional livestock production, it is not possible to make an estimate of the amount of labour required to produce one tonne of meat or eggs - the main traditional products - under semi-traditional conditions. In any case, the use of cattle for draft labour makes it impossible to partition labour required for animal care and feeding into portions attributable to draft labour and meat production.

Based on the NRMP-IEA 30-sector I-O model, it appears that in 1985 some 1.51 million people produced a total of 1.37 million tonnes of animal products (meat, milk and eggs) - this

includes production from both semi-traditional and intensive production technologies (see Table 1). On this basis, labour required per tonne of production was 1.1 person-years, for the sector as a whole. Estimates by Alirahman et al (1992) of livestock production for 1991 suggest that total production (meat, milk and eggs) of 1.71 million tonnes was achieved by an input of 1.42 million person-years of labour - resulting in an estimate of 0.829 person-years per tonne of production.

Data from a study of a relatively small-scale intensive chicken egg production (Simatupang et al 1992) suggests that 42.019 tonnes of eggs and 4.998 tonnes of chicken meat from *over-age* laying hens (total 47.017 tonnes) required 475 days of human labour. This is equivalent to 26.538 tonnes per person-year, or 0.038 person-years (300-day year) per tonne of eggs. To simplify calculations in this instance, the meat is regarded as a 'labour-free' by-product of egg production.

PT Cipendawa, is a major meat and day-old chick producer, with three production facilities and total annual production of 36 million broilers in 1991; in addition they sell 60 tonnes of eggs surplus to hatching requirements. On average, 70% of their meat production is for household consumption (carcass weight 1.15 kg/head), and 30% for restaurants and fast-food outlets (carcass weight 1.55 kg/head); meat from overage layers adds a relatively small amount to total production. This equals total production of 45,720 tonnes/annum of prepared meat, not taking account of production of day-old chicks, over-age layers or eggs. Their total staff in 1992 was 1,300 (including 236 administrative and supervisory personnel). This is equivalent to 35.169 tonnes per person-year, or 0.028 person-years per tonne of production.

For 1985, given these data, this case study will employ a figure of 0.03 person-years per tonne of intensively produced chicken meat and 0.04 person-years per tonne of chicken eggs. In 1985, on this basis (nation-wide), intensive chicken meat production of 130,000 tonnes required a labour force of 3,900 persons; and intensive chicken egg production, estimated at 227,000 tonnes, required a labour force of 9,080 (both including supervisory and administrative staff).

Intensive production of other livestock products (milk and intensive pork) is known to be more labour-demanding than intensive production of chicken meat and eggs. Milk production requires labour on a daily basis for both herding and milking; labour needed for supplementary feeding is minimal as it occurs during milking. Intensive pork production requires labour for feed preparation and distribution and substantial amounts of labour for cleaning stalls and tending piglets. For lack of other data, we assume that producing milk and intensive pork require twice as much labour per unit of production as intensive chicken egg production, i.e. 0.08 person-years per tonne. On this basis, milk production in 1985 (192,000 tonnes, half of which is assumed to be intensive) required a labour force of about 7,680 persons and pork

production (133,000 tonnes, of which half is assumed to be intensive) required an estimated labour force of 5,320 persons.

To provide a basis for comparison between 1985 and 2020 labour requirements, and based the knowledge that non-intensive, semi-traditional livestock production is a part-time activity for most farmers used to generate supplementary income, we assume the 'average' farmer counted in this sector spent 25% of his or her work time looking after livestock. Combining this estimate with macro-level data from the NRMP-IEA I-O table for 1985 for labour employed in the traditional livestock sector (i.e. the full-time labour of 25% of 1.51 million persons) with production of 0.805 million tonnes, gives an average figure of 0.47 person-years per tonne of production. This is still more than ten times the per unit labour requirements for intensive chicken production, where capital in the form of buildings and stockfeed, is substituted for labour. If total full-time employment in the sector in 1985 was 0.377 million and total production 1.370 million tonnes, this gives an average figure of 3.64 tonnes of production per person-year, or 0.28 person-years per tonne.

In summary, in 1985 intensive production of livestock products provided relatively little additional employment in the sector - possibly 26,000 person-years of work. A comparison with estimated total full-time labour in the sector (377,000 persons) indicates that the continuing shift to intensive livestock production shows little promise of providing substantial employment opportunities, despite rapidly rising production.

Stockfeed Production

Over the period 1985-90, the number of registered stockfeed mills remained fixed at 58. However, officials from the Dit. Jen. Perternakan estimate that there are probably an equal number of relatively small, unregistered mills. According to Dit. Jen Perternakan total production (i.e. formulation and processing) of concentrated stockfeed in registered mills increased from 1.425 to 1.599 million tonnes over 1985-90, a net increase of only 12%. In contrast to government estimates, the World Bank (1992) estimated total stockfeed production in 1988 at 5.431 million tonnes, of which about 90% was used in intensive poultry production.

CIC (1992) estimate feed production for chickens by the main feedmiller (Indocommercial) alone had risen to 3.497 million tonnes by 1990 - they consider this to be an underreporting of the company's actual production - with their production growing at over 10% p.a.; approximately 85-95% of total 1990 output from the feedmilling industry as a whole was used for production of chicken meat and eggs (ibid). The same source reports planned expansion of existing national capacity by slightly over one million tonnes/annum within the next one to two years, and new construction already underway for some 77,000 tonnes of additional annual capacity.

Stockfeed Requirements

Because no data on traditional requirements for stockfeed are available, and because the technology of production in the unmodernised sector is expected to remain largely unchanged, attention is focused on estimating stockfeed requirements for modernised, intensive production.

Intensive Chicken Production

Feed Requirements

Based on World Bank (1992) calculations of the composition of rations for livestock and estimates of livestock production (which are significantly different to government estimates of production), one tonne of livestock products required 3.802 tonnes of mixed stockfeed. For intensive poultry meat production the ratio was similar at 3.953 tonnes of feed per tonne of production. For intensive egg production they estimate that 3.817 tonnes of mixed feed is required per tonne of eggs.

Standard parameters on production (Euroconsult 1989) for modern, intensive production give a feed-to-growth conversion factor of 2.05-2.35:1 (average 2.25:1) under tropical conditions. Live weight of mature, ready for slaughter, female chickens is 1.2-1.9 kg (average 1.7 kg), with a *dressing-out* proportion of 80% (live weight:carcass weight). This implies that one kg of prepared meat requires 2.813 kg of mixed feed. Thus, one tonne of feed is sufficient to produce 0.356 tonnes of chicken meat. To allow for lower production efficiencies in less advanced or well-managed facilities, and taking into account the World Bank (1992) estimates, a figure of 3.5 kg of feed per kg of meat produced is used in calculations; i.e. one tonne of feed is sufficient to produce 0.286 tonnes of edible meat.

Chicken meat produced from slaughtering *over-age* laying hens is a by-product of egg production, and requires much less feed per unit of production. However, with the data available it is impossible to partition feed consumed between egg and meat production. In the following calculations it is assumed that feed requirements of this type of meat production are fully accounted for in estimates of feed requirements for intensive egg production.

Chickens used for intensive egg production require 88-97 g/day of feed under tropical conditions (Euroconsult 1989), and this gives a feed-to-egg conversion ratio of 1.62-1.76 (average 1.7) kg/dozen eggs. With an average egg weight of 60 g, this implies a conversion rate of 2.361 kg of feed per kg of eggs. Estimates based on local research (Simatupang et al, 1992), indicate a feed requirement of 3.387 kg/kg of eggs; and the World Bank (1992) estimates give a figure of 3.817 kg/kg of eggs. For this case study a figure of 3.5 kg/kg of eggs is employed - to allow for differences between the available estimates and differences in production efficiency between the mix of highly and less advanced production facilities in

operation. Thus, one tonne of eggs requires 3.5 tonnes of mixed feed, or one tonne of mixed feed is sufficient to produce 0.286 tonnes of eggs.

Water Requirements

In addition to high protein feed, chickens under intensive management also require an adequate supply of clean water to achieve rapid rates of growth and high levels of egg production.

For chickens under intensive management, water requirements are estimated at 0.2-0.3 (average 0.25) litres/day (Euroconsult 1989). For broilers with a life span of 6 weeks, this amounts to 10.5 litres per head, 6.17 litres/kg of prepared carcass, or 6.17 cubic metres per tonne of production. Thus, one tonne of water (one cubic metre) is required to produce 0.162 tonnes of meat. Taking into account water required for other purposes (e.g. cleaning), it is estimated that one tonne of water is sufficient to produce 0.15 tonnes of chicken meat.

In intensive egg production, average production is 265 eggs per head per annum (Euroconsult 1989) or 0.726 eggs/day. With an average egg weight of 60 g, this is equivalent to 0.044 kg/day per head. With an average water requirement of 0.25 litres/day per head, this is equivalent to 5.74 litres/kg of eggs, or 5.74 cubic metres/tonne. Thus, one cubic metre of water is sufficient to produce 0.174 tonnes of eggs. Taking into account water required for other purposes (e.g. cleaning), it is estimated that one tonne of water is sufficient to produce 0.16 tonnes of chicken eggs.

Waste Generation

According to standard parameters (Euroconsult 1989), some 20% of feed supplied to chickens is excreted as waste. Based on the above estimates of feed requirements for intensive chicken meat production (2.813 kg/kg of meat), this implies the production of a kilogramme of meat results in the generation of 0.437 kg of manure, or 0.437 tonnes/tonne of meat. For egg production, where one kilo of eggs requires 2.361 kg of feed, this implies a rate of waste generation of 0.472 kg/kg of eggs, or 0.472 tonnes/tonne of eggs. Estimates based on local research into relatively small-scale intensive egg production (Simatupang et al, 1992), imply a figure of 0.378 kg of waste per kg of production. For this case study, a figure of 0.4 tonnes of waste per tonne of production for both chicken meat and eggs is used.

According to industry sources, there is a ready market for chicken manure, for use in intensive vegetable production, and its disposal is not a problem, nor does it have adverse environmental impacts if used as fertiliser.

Intensive Milk Production

Milk production is less demanding of intensive, processed inputs from other sectors than intensive chicken production, as it relies largely on cattle foraging for themselves, supplemented by processed stockfeed rations.

Efficiency of feed conversion to milk for dairy cattle is not expected to change substantially, as it is limited by biological factors. Based on World Bank (1992) estimates, and assuming one half of the dairy herd received supplementary stockfeed in 1985, one tonne of total milk required approximately 0.271 tonnes of supplementary stockfeed.

III Changes in Technological Coefficients to 2020

Only one scenario (S1) is developed for the livestock sector. There are two reasons for this. First, the technology of non-intensive (i.e. semi-traditional) production of livestock products is not expected to change over 1985-2020. Second, the conversion of stockfeed into meat, milk and eggs is limited by biological factors, and is not amenable to significant changes. Estimates, based on World Bank (1992) projections of demand for livestock products, indicate that there will be little change in the amount of stockfeed required to produce one tonne of meat, milk and eggs over 1985-2020, despite changes in the mix of products. Further technological changes in intensive livestock production, in terms of stockfeed requirements, largely depend on unknowable changes resulting from future application of bio-technology to improving the metabolic conversion efficiencies of livestock.

There is substantial and unresolvable conflict between the various sources on livestock numbers and the production of meat, milk and eggs (to a much greater degree than for other agricultural sectors) that makes the estimation of current (1985) and future technological coefficients problematic. For example, the World Bank (1992) cites the Dit.Jen Peternakan figures on production of meat, milk and eggs for 1988 (937, 443 and 265 thousand tonnes respectively), yet they then base their projections of future demand for these products for 1988-2010 on the following figures (thousand tonnes): 303 plus an unknown amount (meat), 729 (milk) and 385 (eggs); they provide no explanation at all for these differences. Alirahman et al (1992) provide no base data at all, and start their modeling exercise from year 1991 without providing any reference to their sources of data.

Because of these conflicts in data sources on actual levels of livestock production (both by type and overall), we are forced to attempt an estimate of technological changes based purely on isolated and specific data of intensive chicken production from a few commercial sources. Moreover, it appears that the data for 1985 used in the I-O model are for a year when the sector started undergoing a rapid shift in the balance between traditional (extensive) and modernised (intensive) production

The most obvious change in livestock production technology is the increasing importance of intensive production, particularly for chicken meat and eggs. The impact of these changes on the range of inputs required is as follows: processed high-energy and high-protein feeds replacing fodder from grazing or cut-and-carry methods; additional, clean (possibly filtered) water required for maximising growth rates (Eurocconsult 1989), and for cleaning production facilities; additional energy required for lighting (and cooling) production facilities; additional, and more sophisticated, materials required for constructing production facilities; and additional, more highly trained, labour required to operate intensive, increasingly automated, production facilities.

The World Bank (1992) projections for 1988-2010 envisage a very rapid increase in livestock product production. Of particular importance in making estimates of increased demand for stockfeed is the radical increase in production of intensive chicken meat (broilers) they project, because of the dependence on maize and soymeal for feed and the land area needed to grow these crops. They estimate demand increasing at a constant rate of about 10.4% over 1988-2010. Based on recent interviews with industry sources this appears to be too high. Thus, we have reduced the rate of growth used in estimates for intensive chicken meat demand to 9.5% p.a. over 1991-2000, and 9.0% p.a. over 2001-2020. More generally, we have reduced rates of growth in demand for all other types of meat for the 2011-2020 period by 0.5-1.0% p.a. compared to the World Bank's 1988-2010 estimates, to make allowance for slowing population growth and possible production limitations due to lack of land for extensive pasture and for growing stockfeed (see Annex 3 for details).

If we assume that livestock production using traditional methods grows relatively slowly in the years 1985 to 2020, the great bulk of livestock products (meat, milk and eggs) in 2020 will come from intensive production. In 2020, total estimated production from semi-traditional methods is estimated at 1.660 million tonnes (about twice 1985 production of 0.805 million tonnes), or about 16% of total production, the remainder coming from intensive and semi-intensive production (see Annex 2). In 2020 it is estimated that about 10% of total meat production will come from beef (ibid), and possibly 15% of this will be produced under intensive conditions (Soegiono, pers comm.), i.e. only 1.5% of total meat production. To simplify an already complex set of estimations, it is assumed that in 2020 no meat production from cattle, or buffalo, goats, sheep or horses, uses supplementary stockfeed or is prodced under intensive conditions.

In 1985, according to Dit. Jen. Perternakan (1992) data, total production of meat was 808,000 tonnes, of which 130,300 tonnes or 16% came from intensive chicken production (broilers and layers). An additional 178,000 tonnes of meat came from village chickens (ibid), one quarter of which (44,500 tonnes) are assumed (due to lack of data) to have received supplementary

feed. Pork production in 1985 was 133,200 tonnes (ibid) of which one half (66,600 tonnes) is assumed (due to lack of data) to have received supplementary feed. Of total egg production of 369,000 tonnes in 1985, 227,200 tonnes or 61% came from intensive production. And, for lack of more detailed data, half 1985 milk production of 191,900 tonnes (i.e. 96,000 tonnes) is assumed to come from dairy herds receiving supplementary feed.

Based on the World Bank's (1992) demand projections for 1988-2010, extended to 2020 by NRMP, total meat production in 2020 will be about 5.677 million tonnes, of which some 3.170 million tonnes, or 56% will be from intensive poultry (broilers and layers). An estimated 1.003 million tonnes will come from village poultry, three quarters of which (0.752 million tonnes) is assumed to come from chickens receiving supplementary feed. Of the estimated 0.614 million tonnes of pork production in 2020, three quarters (0.461 million tonnes) is assumed to come from pigs receiving supplementary feed.

By 2020, egg production is estimated as 2.886 million tonnes, and all of the increase since 1985 (2.516 million tonnes) is assumed to come from intensive production, which in 2020 is estimated at 2.742 million tonnes. In 2020, milk production is estimated to be 1.911 million tonnes, an increase of some 1.719 million tonnes over 1985, and all dairy herds are assumed to be receiving supplementary stockfeed.

Modified World Bank (1992) estimates for stockfeed consumption (see above) are used in the estimations that follow, adjusted for 1985 levels of meat, milk and egg production based on government (not World Bank) data. However, World Bank (ibid) estimates of stockfeed consumption for 1988 (adjusted to 1985) are used, as government estimates for both 1985 and 1988 appear to be far too low, compared to both World Bank and industry sources.

Stockfeed Requirements

In 1985 it is estimated that 0.565 million tonnes or 41% of total livestock products were produced under intensive conditions. Total stockfeed consumption in 1985 is estimated as 2.515 million tonnes, which if *pro rated* across total livestock production (1.370 million tonnes), gives an estimate of 1.835 tonnes of stockfeed for each tonne of production. Thus, overall, one tonne of stockfeed was required to produce 0.545 tonnes of livestock products.

Livestock production in 2020 under intensive conditions is estimated as 8.815 million tonnes or 84% of total production. If the estimated stockfeed consumption of 33.086 million tonnes in 2020 is *pro rated* across total production (10.475 million tonnes) for 2020, this gives an estimate of 3.159 tonnes of stockfeed for every tonne of production. Thus, overall, it is estimated that in 2020 one tonne of stockfeed will be required to produce 0.317 tonnes of livestock products.

These estimates suggest that the shift to a greater dependence on intensive production will result in a significant increase in stockfeed requirements per tonne of production. Over 1985-2020 it is estimated there will be an increase of about 72% per tonne of production over the study period.

Labour Requirements

The difficulty in estimating labour requirements for semi-traditional livestock production has already been raised, and an estimate of 0.42 person-years per tonne was made, and for intensive milk and pork production an estimate of 0.08 person-years per tonne - these are assumed to remain stable over 1985-2020. Widespread automation of intensive of intensive chicken meat and egg production is highly probable by 2020, and would result in about halving of 1985 labour requirements (PT Cipendawa pers. comm.). This implies that production of one tonne of chicken meat will require only 0.015 person-years and one tonne of eggs 0.02 person-years. Note that here, intensive chicken production does not include production of village poultry (chickens and ducks) receiving supplementary stockfeed, as used in the above estimates of stockfeed requirements.

Total production by semi-traditional methods will approximately double, and total labour employed in this mode of livestock production will also double. Over 1985-2020 production of milk is estimated to increase nine-fold to about 1.911 million tonnes (all from intensive production) increasing employment by almost the same amount. Intensive pork production is estimated to increase by a factor of about seven, and labour employed proportionately. Intensive production of chicken meat (broilers and layers) is estimated to increase by a factor of 24, but automation is expected to restrict additional employment growth to a twelve-fold increase. Intensive egg production is estimated to increase about nine-fold, but automation will restrict employment growth to about 4.5 times 1985 levels.

On the basis of the foregoing estimates, by 2020 labour employed in intensive milk production will increase from about 7,680 to 69,120, and labour employed in intensive pork production from about 5,320 to 37,240. Labour required for intensive chicken meat production is estimated to increase from about 3,900 to 46,800, and for intensive egg production from about 9,080 to 40,860. In total, labour employed full-time in intensive production is estimated to increase from about 26,000 persons in 1985 to about 194,000 persons in 2020, a seven-fold increase.

In 1985, a labour force of some 26,000 produced an estimated 0.520 million tonnes of livestock products (about 38% of total production), equivalent to 19.994 tonnes per person-year, or 0.05 person-years per tonne. In 2020, a labour force of 194,000 is estimated to

produce some 8.429 million tonnes of livestock products (about 80% of total production). This is equivalent to 43.443 tonnes per person-year, or 0.023 person-years per tonne.

With semi-traditional labour requirements remaining at 0.47 person-years per tonne, and production of 1.660 million tonnes, this implies a full-time labour requirement of about 777,000 persons. On this basis, in 2020 the total full-time labour force in the livestock sector is estimated be about 971,000 (194,000 intensive, 777,000 semi-traditional), and total production 10.475 million tonnes. This gives an overall estimate of 10.79 tonnes of production per person-year, or 0.093 person-years per tonne.

For intensive livestock production, the change over 1985-2020 is equivalent to a reduction in labour per tonne of production of about 54% over 1985, mostly due to automation of intensive chicken meat and egg production. For the sector as a whole, labour requirements are estimated to decline from 0.275 in 1985 to 0.093 person-years per tonne in 2020. This is equivalent to a reduction of 66% in labour per tonne of production. As should be clear however, the increase in labour productivity will be wholly concentrated in intensive livestock production, especially poultry.

Water Requirements

The massive increases estimated for intensive chicken meat and egg production suggest that there will be substantial increase in total demand for water; although requirements per tonne of production are unlikely to change significantly. Water requirements for intensive poultry were estimated at 6.25 cubic metres per tonne of production. If intensive chicken meat and egg production increases to an estimated 6.1 million tonnes in 2020, this implies an additional demand for water of about 38 million cubic metres per annum, or some 100,000 cubic metres per day.

In the normal course of events this is not an especially large water requirement. However, in this case it represents an additional demand on clean water resources close to major urban areas, where fierce competition for available resources is already apparent.

Land Use Implications

The recent trend towards intensive livestock production will require significant increases in the amount and proportion of staple crop production (primarily maize and soybean) used as stockfeed. This rising demand has major implications for the extent of land devoted (indirectly) to producing livestock products.

In 1985, nationwide maize production was about 4.3 million tonnes, with a yield of about 1.8 t/ha and required some 2.4 million ha (BPS 1987). Of this total somewhat less than one million tonnes (World Bank 1992) was used for stockfeed, i.e approximately 20% of total

production - requiring some 0.5 million ha of land for its production. Based on World Bank (1992) and NRMP estimates, the demand for maize as stockfeed will increase at an average of 7.3% p.a. over 1988-2020, reaching about 9.7 million tonnes in 2020. If, by 2020, maize yields have reached the level estimated in NRMP Case Study No. 7 (Foley 1993b) of 4 t/ha, maize production for stockfeed will then require some 2.4 million ha.

National soybean production in 1985 was 870,000 tonnes, occupied some 900,000 ha and yields were slightly below one tonne per ha. Of total soybean production about one third was used as stockfeed (World Bank 1992) in the form of soymeal. It should be noted that stockfeed uses soymeal, the solid residue by-product from oil extraction. Based on World Bank (1992) and NRMP estimates, demand for soybean as stockfeed will increase at an average rate of 7.6% p.a. over 1988-2020 to about 2.9 million tonnes in 2020. If, by 2020, yields have risen to 2.6 t/ha, as optimistically estimated in the NRMP Case Study No. 7 (Foley 1993b), soybean production for soymeal stockfeed will then require some 1.1 million ha for production

On this basis, the 2020 level of intensive livestock production is estimated to require a minimum of some 3.5 million ha of agricultural land almost wholly devoted to maize and soybean production, before taking into account additional land area needed for producing other types of stockfeed (e.g. rice bran, mung beans or cassava).

This land requirement should be compared to estimates made by RePPProT (1990) of the extent of the additional land outside Java suitable for agriculture. They estimate approximately one million ha of land suitable for dryland arable cultivation and a further 1.2 million ha available for mixed arable and tree crop agriculture - a total of 2.2 million hectares. Even ignoring land needed for growing other dryland crops for direct human consumption (staples, vegetables and fruit), it is clear that insufficient land will be available to meet the projected demand for growing stockfeed. This implies Indonesia will have to import very substantial amounts of maize and soymeal, for instance, if livestock production, particularly intensive production, is to even approach the levels projected by the World Bank (1992) or Alirahman et al (1992). Alternatively, it implies that either the demand and production projections are overestimated, or that other means of producing the required stockfeed will need to be discovered in coming decades, if imports of stockfeed supplies are to be minimised.

Summary of Technological Coefficients for 1985 and 2020

Estimated technological coefficients for the Livestock Sector for 1985 and 2020, based on the foregoing assumptions and estimations, are summarised below in Table 3. Figures for 2020 are expressed as percentage changes on 1985 coefficients.

Table 3:
Technological Coefficients for Livestock Sector (4) - 1985 and 2020 (percentage change).

			2020
A MATRIX			
4	Livestock, poultry		0
11	Food, beverages & tobacco		+72
18	Petroleum refining		+30
20	Electricity		+30
L MATRIX			
Total employment per unit output			-66
B MATRIX			
Total new capital requirements			+105
N MATRIX			
Water requirements (litres/tonne output)		2,575	+105

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Annex 1:
Intermediate Inputs to the Livestock & Products Sector - 1985.

SECTOR NAME	Sector	M Rp	%
Livestock products	18	1108095	46.0
Other food products	33	317967	13.2
Poultry & products	20	306785	12.7
Retail & wholesale trade	62	270153	11.2
Cereal mill products	30	60600	2.5
Road transport	65	55906	2.3
Petroleum refinery	47	33400	1.4
Sugar cane & brown sugar	8	31880	1.3
Chemicals	46	27307	1.1
Financial intermediaries	70	24700	1.0
Paddy	1	21714	0.9
Other crops	17	17964	0.7
Water transport	66	16422	0.7
Construction	61	15418	0.6
Services allied to transport	68	11528	0.5
Other farm food crops	6	9696	0.4
Other services	74	9583	0.4
Electricity	58	9452	0.4
Machines & electrical machine	55	7756	0.3
Maize	3	5878	0.2
Real estate & bus. services	71	5655	0.2
Wood	21	5382	0.2
Vegetables & fruits	5	4249	0.2
Root crops & flour	4	4182	0.2
Crude coconut & palm oil	10	4878	0.2
Rubber & plastic wares	49	4264	0.2
Wood and cork products	42	3395	0.1
Fabricated metal products	54	2335	0.1
Restaurant & hotels	63	2328	0.1
Air transport	67	1337	0.1
Textile, leather & apparel	37	1126	0.0
Gas utility	59	1123	0.0
Other products n.e.c.	57	1069	0.0
Paper, cardboard & products	44	852	0.0
Railway transport	64	677	0.0
Water supply	60	680	0.0
Woven goods - non-plastic	43	720	0.0
Handpounded rice	2	630	0.0
Non-metalic mineral products	50	503	0.0
Fishery	23	424	0.0
Communication	69	291	0.0
Oil & fat	29	260	0.0
Fertilizer & pesticides	45	30	0.0
Slaughtering	19	16	0.0
Other mining & quarrying	27	13	0.0
Other forest product	22	9	0.0
Sawn and processed wood	38	5	0.0
Social & Community services	73	-	0.0
Total Intermediate Inputs	190	2409781	100.0

Source: NRMP-IEA 75-Sector I-O Model.

Annex 3: Stockfeed Rations and Requirements for Intensive Production.

Table A3.1: Stock Feed Allocations for Intensive Production 1988.
Source: Based on World Bank (1992) and Dit.Jen. Peternakan (1992).

1988	Output x1000 t	Corn x1000 t	Rice Bran x1000 t	Rice x1000 t	Soymeal x1000 t	Gaplex x1000 t	Pollard x1000 t	Other x1000 t	Total x1000 t
Total Dairy	265	33.8	294.5	0.0	0.9	0.0	24.4	134.6	488
Calves		0.0	8.8	0.0	0.9	0.0	0.7	4.2	15
Cows		0.0	32.2	0.0	0.0	0.0	2.6	16.3	51
Adults		33.8	253.5	0.0	0.0	0.0	21.1	114.1	423
Total Pork	154	199.2	818.9	0.0	21.7	0.0	30.3	715.4	1,786
Pigs (modern)		123.6	123.1	0.0	6.6	0.0	0.0	19.6	273
Piglets		1.8	0.6	0.0	0.8	0.0	0.0	0.6	4
Young pigs		18.6	14.7	0.0	1.2	0.0	0.0	5.2	40
Adult pigs		103.2	107.8	0.0	4.6	0.0	0.0	13.8	229
Pigs (village)		75.6	695.8	0.0	15.1	0.0	30.3	695.8	1,513
Confined		75.6	695.8	0.0	15.1	0.0	30.3	695.8	1,513
Poultry (village)	196	131.2	728.2	74.4	39.1	0.0	0.0	162.5	1,135
Intensive		94.0	207.5	0.0	39.1	0.0	0.0	50.9	392
Extensive		37.2	520.7	74.4	0.0	0.0	0.0	111.6	744
Poultry (modern)		622.9	338.7	0.0	221.4	0.0	10.8	273.7	1,468
Eggs	249	330.2	289.9	0.0	123.8	0.0	0.0	181.6	926
Broilers	198	292.7	48.8	0.0	97.6	0.0	10.8	92.1	542
Ducks	10	27.7	337.9	27.7	0.0	55.4	0.0	55.4	554
Total	1,072	1,015	2,568	102	283	55	66	1,342	5,431

Table A3.2: Use per tonne of Intensive Production in 1988, and projections to 2020.
Source: Based on World Bank (1992) and Dit.Jen. Peternakan (1992).

1988	Intens.	Estimated Ration: tonnes per tonne of intensive production						
x1000 tonnes	Prod'n	Corn	Rice Bran	Rice	Soymeal	Gaplex	Pollard	Other
Pork	154	1.291	5.307	0.000	0.141	0.000	0.196	4.636
Village Poultry	206	0.771	5.415	0.495	0.190	0.269	0.000	1.057
Modern Poultry	198	1.481	0.247	0.000	0.494	0.000	0.055	0.466
Milk	265	0.128	1.112	0.000	0.003	0.000	0.092	0.508
Eggs	249	1.327	1.165	0.000	0.497	0.000	0.000	0.730
Total Intensive	1,072	0.947	2.396	0.095	0.264	0.052	0.061	1.252

Table A3.3: Estimated Requirements of Stockfeed for Intensive Production 1985.

1985 x1000 tonnes	Intens. Prod'n	Estimated stockfeed required for intensive production							Overall Total
		Corn	Rice Bran	Rice	Soymeal	Gaplex	Pollard	Other	
Pork	67	86	353	0	9	0	13	309	771
Village Poultry	45	34	241	22	8	12	0	47	365
Modern Poultry	130	193	32	0	64	0	7	61	357
Milk	96	12	107	0	0	0	9	49	177
Eggs	227	301	265	0	113	0	0	166	845
Total Intensive	565	627	998	22	196	12	29	631	2,515
Total Production	1,370								
% Intensive	41.2%								
					Stockfeed/Total Prod'n				1.835 t/t

Table A3.4: Estimated Requirements of Stockfeed for Intensive Production 2020.

2020 x1000 tonnes	Intens. Prod'n	Estimated stockfeed required for intensive production							Overall Total	
		Corn	Rice Bran	Rice	Soymeal	Gaplex	Pollard	Other		
Pork	461	595	2,446	0	65	0	90	2,136	5,332	
Village Poultry	752	580	4,072	373	143	202	0	795	6,165	
Modern Poultry	3,170	4,696	783	0	1,566	0	173	1,478	8,696	
Milk	1,911	244	2,125	0	6	0	176	971	3,522	
Eggs	2,520	3,343	2,935	0	1,253	0	0	1,839	9,370	1985-2020
Total Intensive	8,815	9,458	12,361	373	3,033	202	440	7,219	33,086	net %
Total Production	10,475									
% Intensive	84.2%									
					Stockfeed/Total Prod'n				3.159 t/t	72.1%

Annex 4: Stockfeed Demand Projections 1988-2020.

Table A4.1: Maize Stockfeed Demand Projections 1988-2010 (World Bank 1992, extended to 2020).
Source: Based on World Bank (1992) for 1988-2020 and NRMP estimates for 2011-2020.

2020	1988 x1000 t	1988-95 rate p.a.	1995 x1000 t	1995-2000 rate p.a.	2000 x1000 t	2001-05 rate p.a.	2005 x1000 t	2006-10 rate p.a.	2010 x1000 t	2011-20 rate p.a.	2020 x1000 t	1988-2020 rate p.a.	1988-2020 net %
Dairy	34	5.36%	49	4.12%	65	4.25%	87	4.32%	117	4.5%	182	5.38%	434.4%
Eggs	358	6.79%	567	4.55%	774	4.30%	1,039	4.05%	1,372	4.0%	2,031	5.57%	467.3%
Pork	199	5.42%	288	5.70%	380	5.81%	504	5.73%	666	5.5%	1,138	5.60%	471.7%
Village Poultry	131	5.14%	186	5.40%	242	5.55%	317	5.43%	413	5.0%	673	5.25%	413.5%
Modern Poultry	293	9.41%	550	10.01%	886	10.37%	1,451	10.43%	2,383	9.0%	5,641	9.68%	1825.4%
Total	**1,015**	**7.09%**	**1,640**	**7.43%**	**2,347**	**7.68%**	**3,398**	**7.82%**	**4,951**	6.9%	**9,664**	7.30%	852.2%

Table A4.2: Soymeal Stockfeed Demand Projections 1988-2010 (World Bank 1992, extended to 2020).
Source: Based on World Bank (1992) for 1988-2020 and NRMP estimates for 2011-2020.

2020	1988 x1000 t	1988-95 rate p.a.	1995 x1000 t	1995-2000 rate p.a.	2000 x1000 t	2001-05 rate p.a.	2005 x1000 t	2006-10 rate p.a.	2010 x1000 t	2011-20 rate p.a.	2020 x1000 t	1988-2020 rate p.a.	1988-2020 net %
Dairy	1	0.00%	1	10.41%	2	0.00%	2	5.96%	3	5.0%	5	5.08%	388.7%
Eggs	124	6.76%	196	4.57%	268	4.31%	360	4.04%	475	4.0%	703	5.57%	467.0%
Pork	22	5.02%	31	5.75%	41	6.05%	55	5.83%	73	5.5%	125	5.57%	466.8%
Village Poultry	39	5.30%	56	5.15%	72	5.70%	95	5.30%	123	5.0%	200	5.25%	413.7%
Modern Poultry	98	9.33%	183	10.10%	296	10.33%	484	10.41%	794	9.0%	1,880	9.67%	1818.0%
Total	**284**	**7.36%**	**467**	**7.77%**	**679**	**7.96%**	**996**	**8.07%**	**1,468**	7.1%	**2,913**	7.55%	925.6%