

# Chapter 9

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## Livestock and Fisheries

Early Chinese references, archaeologists, and anthropologists place the Tai in valleys with wet rice cultivation. Livestock, particularly bovines are thought to have been significant for rituals, wealth, and status more than draught power.<sup>1</sup> Fish were a naturally available protein source. Technological developments, including improved plough designs and materials from Vietnam, later increased reliance on draught bovines, particularly buffalo (*Bubulis bubilis*). Modern agricultural intensification, which has incidentally displaced the buffalo, has created an advanced livestock subsector of Thai agriculture and agribusiness.<sup>2</sup> Meanwhile, small-holder livestock has become a subsidiary industry in the case of bovines, a subsistence industry for poultry and even pigs raised under low margin conditions, or a labour-based industry for contract broiler and pig production. Coastal and freshwater Thai fishers sustainably harvested food resources for centuries, until new harvesting technologies allowed over-exploitation in recent decades, leading to an aquaculture industry which now serves export and domestic markets.

### Production Systems

Livestock induced environmental change is recent. From a situation of minimising clearing of *Dipterocarp* forest for both land care and shade for cattle and buffalo,<sup>3</sup> the Northeast was changed into a largely treeless plateau. Once an essential component of life and family supported by laws to restrict their slaughter,<sup>4</sup>

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<sup>1</sup> Wyatt, D.K. (1988)

<sup>2</sup> Kaosaard, Mingsarn and Rerkasem, Benjawan (1999)

<sup>3</sup> Pendleton, R.L. (1943)

<sup>4</sup> Nakajud, A. (1962)

partly in adherence to Buddhist preclusions of killing sentient beings,<sup>5</sup> cattle are now raised to supply a growing middle-class market for beef. Past animal husbandry techniques criticised for their lack of consistency with modern disease control, including for chickens and pigs,<sup>6</sup> may now be seen as a moral conflict which inhibited the development of meat industries prior to the 1950s.<sup>7</sup> Fish, the preferred source of animal protein, did not require a deliberate act of killing.

Thai livestock production systems<sup>8</sup> extend from semi-domesticated poultry and pigs which essentially fend for themselves around villages in swidden and shifting agricultural systems, through the most wide-spread livestock production system in Asia, rainfed agriculture, with livestock supplying manure, stubble removal, puddling, land preparation, and capital accumulation services, and pigs, poultry, and small ruminants consuming agricultural waste. Irrigated agriculture provides higher levels of by-products for livestock feed, and in recent decades has shown the most rapid development of livestock industries. Plantation agriculture includes poultry, pigs, goats, and sheep utilising plantation by-products such as coconut cake, palm kernel cake, and molasses. Contract farming in the vertically integrated poultry and pig industries also applies marginally to beef and dairy. Fish are raised in conjunction with rainfed, irrigated, contract, and commercial systems, as is an unsustainable form of shifting aquaculture, and fish capture. Non-traditional livestock includes deer, crocodiles, snakes, rabbits, quails, pheasants, and other game animals for meat, as well as elephants, monkeys, and horses for work and entertainment purposes.

Over the past three decades, animal agriculture in Thailand has changed as dramatically as that of crops. While intensification is evident in both sectors, and in particular in the production of poultry meat, the major change has been a cultural shift in the role of agricultural animals, from integrated components of farms and families to one of discreet production units. In common with cropping, Thai animal production may now be divided between two agriculture systems, industrial animal production and subsistence.

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<sup>5</sup> Buranamas, P. (1963)

<sup>6</sup> Ingersoll, J. (1966)

<sup>7</sup> Pfanner, D.E. and Ingersoll, J (1962)

<sup>8</sup> ADB (1991)

Traditional non-fish livestock production continues to be practiced in neighbouring Lao-PDR, providing a model for aspects of self-sufficient agriculture<sup>9</sup> in integrated agricultural and natural systems.<sup>10</sup> Large livestock are raised under free range with variable levels of care,<sup>11</sup> while small livestock including pigs, poultry, and goats are raised under scavenging systems with some penning. While Lao-PDR systems reflect market<sup>12</sup> opportunities afforded by neighbouring countries, they continue to accommodate the narrow capital base of Lao-PDR and traditional values of Tai people.

## Production Levels

Thailand ranked sixth in terms of cattle numbers, third for buffalo, fifth for pigs, sixth for sheep, tenth for goats, fourth for chickens, and fourth for ducks out of twelve Asian countries (Table 9.1) in 1993.<sup>13</sup> Thailand's advantage lies in its feed production base for chickens, pigs, and to a smaller extent, bovines.

**Table 9.1** Livestock Numbers by Type for Selected Asian Countries in 1993<sup>14</sup>

	<b>Cattle</b> '000	<b>Buffalo</b> '000	<b>Pigs</b> '000	<b>Sheep</b> '000	<b>Goats</b> '000	<b>Chickens</b> million	<b>Ducks</b> '000
Bangladesh	239,323	866		989	25,967	109	14,441
Cambodia	2,468	804	2,043			10	3,800
China	82,641	22,217	393,965	109,720	97,812	2,688	429,719
India	192,700	78,555	10,547	44,608	117,547	435	
Indonesia	11,000	3,452	8,200	6,300	11,800	620	30,000
Lao-PDR	1,010	1,167	1,559		144	9	327
Malaysia	735	186	2,983	308	352	95	12,500
Pakistan	17,779	18,740		27,668	40,225	92	3,195
Philippines	1,781	2,561	7,954	30	2,562	65	8,394
Sri Lanka	1,600	870	90	19	500	9	40
<i>Thailand</i>	<i>7,190</i>	<i>4,747</i>	<i>4,800</i>	<i>136</i>	<i>151</i>	<i>134</i>	<i>16,000</i>
Vietnam	3,320	2,956	14,861		300	83	29,800

<sup>9</sup> Bangkok Post (1999)

<sup>10</sup> Simaraks, Suchint (1998)

<sup>11</sup> Pravongviengkham, Parisak (1998)

<sup>12</sup> Ponvisay, Singkham (1998)

<sup>13</sup> FAO (1995a)

<sup>14</sup> FAO (1995a)

The contribution of livestock to GDP for the years 1971 to 1993 (Table 9.2) indicate declines in the proportions originating from hens, ducks, and eggs while all other categories increased.<sup>15</sup> Such statistics suit the intensive vertically integrated production systems of pigs and poultry but may not capture contributions such as draught power in subsistence agricultural systems.<sup>16</sup> Such uncalculated economic benefits from livestock include; wool, hair, hides, pelts, edible fat, horns, hooves, bones, tankage, endocrine extracts, draught power, traction, herding, irrigation, pumping, threshing, transportation, fertiliser, fuel, gas production, plaster, feed stuffs, capital gains, grassland conservation, seed distribution, clearing aquatic plants, weeding, snail control, social benefits, sporting, fighting, hunting, pets, racing, riding, religious purposes, bride price, and social status.<sup>17</sup>

**Table 9.2** *Livestock Contributions to GDP (Billion Baht, 1988 Prices)<sup>18</sup>*

Year	Bovines	Swine	Poultry	Eggs	Dairy	Other	Total
1971	1.4	0.8	1.4	0.7	0.009	0.1	4.3
1981	6.4	6.3	2.5	2.8	0.08	0.3	18.3
1991	11.3	6.5	6.1	4.0	0.5	1.1	29.4
1993	11.6	7.4	6.7	4.5	0.5	1.3	32.1

The estimated farm value of livestock products in 1996 was; buffalo 2.6 billion baht, cattle 8.6, pigs 40.5, poultry 41.5 (1995), eggs 21, fresh milk 3.2, freshwater fish 9.7 (1994), and marine fish 77.3 (1994).<sup>19</sup>

## Buffalo and Cattle

Related to the cattle of neighbouring countries<sup>20</sup> rather than representing a specific breed,<sup>21</sup> Thai cattle vary across the country as a result of exotic crosses with European and, to a lesser extent, Indian and Chinese lines from trading ships from the eighteenth century, and the importation<sup>22</sup> of a range of breeds from the

<sup>15</sup> NESDB (1994)

<sup>16</sup> Falvey, L. (1983)

<sup>17</sup> McDowell, R.E. (1977)

<sup>18</sup> NESDB (1994)

<sup>19</sup> Office of Agricultural Economics (1998)

<sup>20</sup> Epstein, H. (1969)

<sup>21</sup> Rife, D.C. (1960)

<sup>22</sup> Chantalakhana, Charan (1993)

1950s. Buffalo lines are less controversial as the species attracted less attention from Western educated authors of the 1950s and 1960s.<sup>23</sup> Early reports note the separate roles of cattle and buffalo according to wetness of working conditions and heat stress.<sup>24</sup> Crossbreeding of the Thai swamp buffalo with the river species, Murrah, to produce more milk for human consumption<sup>25</sup> reflects foreign animal production influence.<sup>26</sup> By the late 1960s, cattle and buffalo trading became evident<sup>27</sup> in response to the meat demands of the USA military presence. Nevertheless, bovines continued to be managed simply in comparison with the intensive systems introduced to the poultry and pig industries in the 1980s. Such low management requirements of native cattle<sup>28</sup> favoured their long retention in remote areas.

Exports of bovines from Thailand is recorded from the nineteenth century, increasing through the early part of the twentieth century. Cattle originating in central and eastern Thailand were assembled and traded by Indians who enjoyed some special privileges as British subjects, including immunity from legal penalties associated with receiving stolen cattle and failure to pay tax.<sup>29</sup> In 1897, government legislation targeted three identified concerns in the trade of bovines, namely, treatment of animals, cattle theft, and the spread of infectious disease, to little effect as cattle trading re-routed around the official Bangkok port.

A boom in demand for export cattle in the 1920s led to a three-fold increase in cattle prices paid to traders who appear to have colluded to minimise any increase in prices paid to farmers.<sup>30</sup> Trade in cattle was restricted by government from 1935 when annual exports of live animals and hides were estimated to be some seven million and one million baht. By the 1960s, cattle export was estimated to be less than 7,000 head per year<sup>31</sup> when the economy began to expand thus soon creating large-scale illicit bovine trading.<sup>32</sup>

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<sup>23</sup> Rufener, W.H. (1971)

<sup>24</sup> Buranamas, P. (1963)

<sup>25</sup> Boonlong, Siribongse (1963)

<sup>26</sup> Bhannasiri, Tim (1970)

<sup>27</sup> Rufener, W.H. (1971)

<sup>28</sup> Falvey, L. et al (1979)

<sup>29</sup> Credner, W. (1935)

<sup>30</sup> Tomson, V. (1967)

<sup>31</sup> Donner, W. (1978)

<sup>32</sup> Falvey, L. (1981a)

Changes also related to technology, such as the need for buffalo to draw larger and stronger implements for cultivation of the larger plots of high clay soils as the Central Plain were settled.<sup>33</sup> Paired bovine ploughing in the South reflects Indian influence, or even European experience with multiple animals to pull the deep mould board ploughs of the European agricultural revolution. Likewise, the use of cattle rather than buffalo to plough paddy fields in the North may reflect associations with Indian cattle traders.<sup>34</sup> Thai buffalo, once claimed as the world's largest,<sup>35</sup> declined in stature as larger-framed young bulls were castrated in case they later proved intransigent.<sup>36</sup> Nevertheless, the Thai buffalo and the Thai agricultural system have evolved to mutual benefit. Buffalo heat fatigue is managed through work breaks which seem to suit both farmer and animal who develop a bond as they grow old together.<sup>37</sup>

Early development assistance<sup>38</sup> supported disease control, pasture improvement, and animal breeding. However, governmental allocations to the Department of Livestock Development<sup>39</sup> appeared to benefit agribusiness houses while small farmers relied on livestock for subsistence, a small cash income, and saving. Livestock industries grew with post-World War II demand although control of meat sales by Bangkok-based trading groups,<sup>40</sup> compounded with inappropriate government regulations, confused price signals received by small-holders. A famous area of corruption,<sup>41</sup> the buffalo and cattle industries consistently failed to fulfil their potential as other livestock industries modernised.

Subsequent development of the large ruminant industries of Thailand followed the patterns of countries receiving aid in Africa, Latin America, and elsewhere in Asia. The centrality of livestock in integrated social and agricultural systems was poorly understood.<sup>42</sup> An exceptional input in this non-irrigated sector by the World Bank<sup>43</sup> enhanced livestock production through improved forage,

<sup>33</sup> Montrakun, Sarot et al (1971)

<sup>34</sup> Falvey, L. (1985)

<sup>35</sup> Donner, W. (1978)

<sup>36</sup> Chantalakhana, Charan (1979)

<sup>37</sup> Cockrill, W.R. (1974)

<sup>38</sup> World Bank (1959b)

<sup>39</sup> Silcock, T.H. (1970)

<sup>40</sup> Muscat, R.J.(1996)

<sup>41</sup> Silcock, T.H. (1970)

<sup>42</sup> Orskov, E.R. (1993)

<sup>43</sup> World Bank (1983c)

genetic upgrading, and disease control throughout the Northeast. Extensive development of legume-based pastures, crossbreeding with larger framed Brahman and Holstein-Friesian breeds, and strengthened veterinary services was supported by the creation of a cadre of practical departmental livestock specialists. The project demonstrated early benefits, and its influence continues to be evident as poor Northeast farmers produce dairy cross-bred calves for the Central Plain dairy industry, while maintaining the national bovine breeding base as other regions reduced breeding cow numbers.

Modernisation of livestock industries paralleled similar trends in cropping, which in themselves also impacted on livestock. At the cost of reduced animal numbers,<sup>44</sup> the mechanisation of wet rice production introduced such benefits as; increased labour output and income, timely operation by tractor ploughing of hard dry soils, expanded land areas accessible to agriculture, reduced land required for livestock feed and forage, and meeting peak labour requirements at transplanting and harvest.<sup>45</sup> In this transition from animal to mechanised power in rice agriculture, differences were seen as; higher capital investment requirements for machines, higher operating costs for animals, limitations in machine adaptability to varied environments, a depreciating asset replacing a self-reproducing and profit making asset, the pre-empting of any alternative mixed livestock and machine systems, and less tangible losses of contact with another sentient being, traditions, and other social assets.

However, double cropping required faster work than animal power produced, and provided such financial advantages that rapid replacement with 'iron buffalo' tractors was inevitable. Once adopted in an area, past influence of the working animal component of integrated small-holder farming became clear from increases in plot and farm size, and cropping intensity. Two-wheeled tractors were initially employed in double-cropped rice production, although they soon were purchased for convenience and status reasons as well, leading to the disappearance of bovines from many Thai landscapes.

Bovine disappearance in Thailand was associated not only with substitution by tractors, but by; disease-related closure of live cattle exports to

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<sup>44</sup> Falvey, L. (1985)

Singapore and Hong Kong, rising preferences for Western styles of meat presentation, market corruption causing low farmer receipts from bovine sales, inadequate integration of small-holders with the wider meat industry, modernisation of savings mechanisms and religious rituals, and inefficient government support services. The successful Northeast pilot project, which adapted management and breeding technologies to small-holders, demonstrated means of slowing the rate of disappearance.<sup>46</sup>

Traditional Thai diets contained little red meat as fish was the preferred animal protein. Red meat was consumed primarily as small pieces cooked in mixtures of vegetables or curries. Tastes in recent decades have made beef a product in its own right, accelerating the demise of the buffalo which modern palates deem inferior, except for a lingering preference in the North. Models of bovine disappearance<sup>47</sup> in the 1980s indicated severe shortages of mature male cattle in the South and likely shortages of buffalo in the Northeast and Central Plain. Potential shortages of draught animals was an unexpected outcome of mechanisation which was assumed to directly substitute for those tasks necessary for crop production at higher levels of efficiency (Table 9.3).<sup>48</sup>

**Table 9.3** *Hours per Rai for Paddy Ploughing by Tractors and Buffalo*<sup>49</sup>

Rice Type	Large Tractor	Medium Tractor	Small Tractor	Buffalo
Transplanted Paddy	0.9 - 1.0	2.5 - 2.6	2.7 - 3.3	15.6 - 20.5
Broadcasted Paddy	0.5 - 0.6	2.1 - 2.2	2.3 - 3.1	11.3 - 17.9
Upland Dry Rice	1.3 - 1.6	2.4	3.4 - 3.6	12.6 - 17.6

Numbers and production of buffalo and cattle (Table 9.4) indicate the effect of mechanisation on buffalo, and the alternative use of cattle for meat. The majority (78 percent) of buffalo are in the Northeast, which also supports 39 percent of the cattle with 25 and 22 percent in the North and Central Plain respectively.<sup>50</sup>

<sup>45</sup> Stout, B.A (1966)

<sup>46</sup> World Bank (1985a)

<sup>47</sup> Manowalailao, Koset and Juntaravong, Boonmee (1982)

<sup>48</sup> Moerman, M. and Miller, P.L. (1989)

<sup>49</sup> Manowalailao, Koset and Juntaravong, Boonmee (1982)

<sup>50</sup> Office of Agricultural Economics (1998)

**Table 9.4** Numbers and Production of Buffalo and Cattle, 1993 - 1998 ('000 head)<sup>51</sup>

Year	Buffalo		Cattle	
	Population	Production	Population	Production
1993	-	0.53	-	1.02
1994	4.66	0.44	6.80	1.18
1995	4.18	0.41	6.82	1.16
1996	3.73	0.36	6.88	1.19
1997	3.0 est	0.31	6.8 est	1.13
1998	2.0 est	0.28	6.8 est	1.06

Vaccinations administered by the Department of Livestock Development have declined from nearly eight million to some five million for buffalo over the period 1987 - 1996 while increasing coverage as the buffalo population declined. Meanwhile, cattle vaccination levels rose from some eight million to 11.5 million reflecting a greater degree of epidemic disease control.<sup>52</sup> Control of Foot and Mouth Disease, long recognised as a priority for Thai livestock development, improved from 1958 when identification of the specific causal FMD type allowed production of a cattle, and later a buffalo, vaccine.

Breeding management was addressed through government artificial insemination programs which introduced Brown Swiss, Red Sindi, Brahman, and other breeds during the 1950s to complement earlier introductions of small numbers of Zebu and Jersey cattle prior to World War II. Red Danish cattle and Murrah buffalo were also introduced as part of these general cross-breeding programs which aimed to increase production following conventional Western quantitative genetics in support of quantifiable economic benefits. Improved nutrition was based on imported technologies for adaptation to the Thai environment and led to a strong reliance on grass rather than legume species, and a focus on mineral deficiencies rather than protein or non-protein nitrogen. Some studies indicated economic benefits from appropriate nutritional management without sophisticated cross-breeding programs,<sup>53</sup> and concerns were raised about bovine losses from the wet rice farming system.<sup>54</sup>

<sup>51</sup> Office of Agricultural Economics (1998)

<sup>52</sup> Department of Livestock Development (1997)

<sup>53</sup> Falvey, L. (1982a)

<sup>54</sup> Patanapongsa, Narinchai (1983)

Government cattle development projects have been frequently quoted for institutionalised corruption and inadequate technical advice. Promotion of small-holder purchase of imported cattle using credit resulted in widespread indebtedness following the allocation of imported animals to small farmers with inadequate management resources. In many cases, unadapted animals were known to be unlikely to be productive in that environment. In another case, the low educational levels of small-holders made them easy dupes for speculative manipulation of prices for cattle which provided no production benefit, such that upon the inevitable peak of the fashion, losses accumulated to them; prices fell significantly, such as 50,000 to 20,000 baht for Droughtmaster, 70,000 to 20,000 baht for American Brahman, and 500,000 to 20,000 baht for Indu Brazil.<sup>55</sup>

Cattle production is mainly associated with non-irrigated agriculture including the poverty areas of highland northern Thailand<sup>56</sup> where rectification of primary mineral nutritional deficiencies can increase production more than 30 percent with additional reproductive increases of more than 30 percent.<sup>57</sup> Similarly the widespread poverty of the Northeast, where most bovines are produced,<sup>58</sup> has led to considerable research on cattle nutrition, breeding, and management. Potential for continued increases in the efficiency of livestock production in marginal areas exists; available labour and crop by-products can be better used, and beef production could be linked to the developing dairy industry by providing males for quality meat while females provide milk production and bulk meat.<sup>59</sup> In the South, the fighting bull sport has assisted retention of a local breed type.<sup>60</sup>

Indigenous cattle have been falsely assumed to be unresponsive to improved nutrition, health and management, and therefore inferior to exotics. Naive comparisons of live-weight gain rates under favourable conditions have been biased by differing breed mature live-weights, unobserved differences in the efficiency of conversion of rough feed, and in terms of rural social requirements. The high rates of gain per unit live weight and early maturity at smaller sizes of indigenous cattle

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<sup>55</sup> Paopongsakorn, Nipon et al (1995)

<sup>56</sup> Falvey, L. (1986a)

<sup>57</sup> Falvey, L. (1985)

<sup>58</sup> Rufener, N.H. (1971)

<sup>59</sup> Na Phuket, Suntraporn. (1999)

<sup>60</sup> Chantalakhana, Charan. et al (2000)

<sup>61</sup> Falvey, L. (1982a)

offer several advantages to small-holders, including:

- productivity - live-weight gains which, when calculated on an area basis or relative to live weight, exceed those of introduced breeds<sup>61</sup>
- adaptability - suited to local regimes in terms of dietary tolerance and compatibility with farmers
- divisibility - allowing the raising of urgent cash by sale of one animal without disrupting a small breeding unit
- heat tolerance - in addition to the physiological adaptations of *Bos indicus*, small size provides a higher skin area to body volume ratio which facilitates cooling
- fecundity - the ability to produce a calf each year, to nurture these small calves well, and to remain unperturbed by human involvement<sup>62</sup>
- disease resistance - herd ability to survive epidemics
- independence - ability to forage for basic nutritional requirements without the need of supplements to induce oestrous cycling or to withstand epidemics.

Notwithstanding these advantages, widespread crossbreeding has produced a national herd which includes introduced *Bos indicus* and some *Bos taurus* genetic material from a range of beef, milk, and dual purpose breeds. Farmers operating in a semi-subsistence environment would have done better from selection within indigenous types than they have from exotic introductions of government and speculators. However, potential to link small-holders to supply intensive dairy and beef production systems suggests inevitable modification of the sector, which will necessitate improved small-holder management skills, improved natural resource management, supplementary feeds, and other inputs.

Development strategies for beef cattle and buffalo are currently based on a strategy which provides for : special attention to bovines in border regions through fattening, quarantine and forage development; a review of outdated legislation concerning draught and traction animals, breed improvement, slaughtering and marketing facilities, animal and carcass movements; markets and marketing in terms of cleanliness, consumer education, producer cooperatives and export of live animals and meat; and slaughterhouse improvement in standards, quality, and sanitation. Promotion of improved production through credit, extension and an enhanced

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<sup>62</sup> Falvey, L. (1981a)

role for the private sector, creation of a bovine fund for research, development and farmer credit, conservation of buffalo and indigenous cattle, and research and development, support the strategy.<sup>63</sup> With improved cognition of global trends, improved departmental efficiency, and strategic policy application, Thailand is well placed to be a major beneficiary<sup>64</sup> of the large forecasted increase in demand for livestock and livestock products in Asia.<sup>65</sup>

## Dairy

The Thai dairy industry has developed from milk being a product for children and the infirm,<sup>66</sup> through a period when Thai adults were said to be lactose intolerant, to today's expanding small-holder industry.<sup>67</sup> Sustained by Thai Indians with a tradition of milking cattle and goats, the industry was neglected by government until Danish and German foreign aid with Thai scientists introduced appropriate technologies in the Central and the North regions respectively<sup>68</sup>. Decades of local adaptation produced technologies suited to small scale dairying, including collection and processing cooperatives. The absence of vested interests and unbiased screening of credit applicants through BAAC ensured that early entrants to dairying had potential to benefit from their investments, thereby providing confidence to other prospective entrants.

The industry is now underpinned by a concerned research sector,<sup>69</sup> and is seen as in other similar countries, as possessing a viable future<sup>70</sup> hitherto unrecognised by most development agencies.<sup>71</sup> Expansion through 1993 - 1997 included rises in: cooperative members from 15,300 to 23,500, numbers of farms from 9,800 to 17,500, numbers of dairy cows from 126,000 to 307,000, and numbers of cows milked from 56,000 to 130,000. Over that period, the production rose from 157,000 tons to 194,000 tons and price rose from eight baht to 9.3 baht per

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<sup>63</sup> Ministry of Agriculture and Cooperatives (1999)

<sup>64</sup> Falvey, L. (1999)

<sup>65</sup> Delgado, C. et al (1999)

<sup>66</sup> Donner, W. (1978)

<sup>67</sup> Falvey, L. and Chantalakhana, Charan (1999)

<sup>68</sup> Smith, H.D. (1963)

<sup>69</sup> Chantalakhana, Charan (1999)

<sup>70</sup> Skunmun, Pakapan., Boonsom, J., Keawsuwan S. and Chantalakhana, C. (1999)

<sup>71</sup> Falvey, L. (1999)

litre, produced an increase in farm value received from 1.2 billion baht to 1.8 billion baht.<sup>72</sup> Cooperatives, other than those of the semi-government Dairy Farming Promotion Organisation of Thailand, produced some 56 percent of milk in 1997; the value and quantity of fresh milk and numbers of cows and cooperative members and farms for 1997 are presented in Table 9.5.

**Table 9.5** *Producer Members, Farms, Cows, Milk Production and Value in 1997*<sup>73</sup>

Collection Point	Number of Members	Number of Milk Farms	Number of Dairy Cows	Tons of Fresh Milk	Value million baht
<b>DFPO:</b>					
Muaklek	1,993	1,776	34,296	22,296	219.7
Prachuap	1,062	855	13,416	9,297	93.1
Chiang Mai	120	114	1,187	988	9.1
Khon Kaen	669	588	6,823	4,339	40.6
Sukhothai	176	154	1,664	429	4.0
<b>Total DFPO</b>	<b>4,020</b>	<b>3,487</b>	<b>57,386</b>	<b>37,382</b>	<b>366.5</b>
Other Coops	15,315	10,092	170,664	110,834	1,021.3
Education Inst'ns	88	88	2,418	1,195	11.1
Others	4,159	3,820	76,362	45,003	416.6
<b>Total</b>	<b>23,528</b>	<b>17,487</b>	<b>306,830</b>	<b>194,416</b>	<b>1,815.5</b>

Small-holder dairying differs from other industries as the daily output is 90 percent water, perishable, and is highly priced in industrial, food, and health markets. As small-scale producers are vulnerable to market changes, cooperative processing appears critical to success. Its sustainability poses complex political, socio-economic, educational, and technical questions,<sup>74</sup> yet the benefits that have accrued are highly congruent with other espoused plan objectives, such as:

- year round engagement of rural and peri-urban labour
- utilisation of agricultural and other by-products
- integration with cropping systems management
- conversion of by-products to organic manure for application to crops
- provision of nutritious and hygienic food for children
- production of meat from male calves and older cows
- reduction of meat costs as draught power declines as the primary bovine product
- providing rural and peri-urban industrial development through milk factories

<sup>72</sup> DFPO (1998)

<sup>73</sup> DFPO (1998)

<sup>74</sup> Egan, A.R. (1999)

- developing new products for niche exports
- reducing rural to urban population drift
- providing draught and traction as a dairy industry by-product or adjunct
- allowing landless persons to make a reasonable local living from dairying.<sup>75</sup>

The future of the Thai dairy industry in the 1990s depends on improvements in survival rates, reproductive rates, feed quality, and genetics,<sup>76</sup> and wider use of agricultural by-products of the sugar,<sup>77</sup> oil palm, and rubber<sup>78</sup> industries. More full-time dairy farmers will be required in the view of some analysts<sup>79</sup> and these are likely to be farmers who manage risk through family-wide systems in a range of agricultural enterprises.

## Pig

Prior to the introduction of European breeds, the Chinese Black Pig (*Sus indicus*)<sup>80</sup> was spread widely throughout Thailand. Today commonly viewed as inferior, poorly bred, and of limited productive use, the breed has been maligned in comparisons with European pork producing breeds, and is now largely restricted to poorer hilltribe villages. Nevertheless, this so called native pig combined the essential elements of disease and parasite resistance, fecundity, scavenging capability, compatibility with village life, ability to grow quickly when nutrition was favourable, and early maturity with associated capacity for high levels of fat deposition.<sup>81</sup> As fat was a major dietary component derived from these animals, the pig was well suited to the Chinese, and to a lesser extent, the Thai, diet.

Studies with residual indigenous pigs kept in highland villages of the North indicated a continuing preference for fat production as recently as the 1980s<sup>82</sup> which carcass studies confirmed.<sup>83</sup> Raising indigenous pigs on a locally produced

<sup>75</sup> Falvey, L. (1999)

<sup>76</sup> Yamada, Y. (1988)

<sup>77</sup> Kawashima, T. (1996)

<sup>78</sup> Devendra, C. (1992)

<sup>79</sup> Kumagai, H. and Ngapongsai, Wanwisa (1998)

<sup>80</sup> Davidson, H.R. (1966)

<sup>81</sup> Falvey, L. (1981d)

<sup>82</sup> Visitpanich, Theera. and Falvey, L. (1980)

<sup>83</sup> Falvey, L. and Visitpanich, Theera (1980a)

pigeon pea with intestinal parasite control<sup>84</sup> indicated potential for improved production which was substantiated<sup>85,86,87</sup> and recommended<sup>88</sup> for development options. However, the residual pool of these animals continued to shrink, such that it is now the subject of genetic resource studies. Scope for crosses with later maturing animals remains for pigs produced in self sufficient or near subsistence family units.

Lowland rural Thai households each maintained an average of 1.4 pigs in 1960 under conditions of poor disease and nutritional management. In 1970, the under-estimated 3.7 million pigs were located in the Central Plain (59 percent) and the Northeast (41 percent). A prior dominance of the Northeast<sup>89</sup> had been usurped by the growing concentrations of pigs around Nakhon Pathom, Sing Buri, and Saraburi, heralding future large-scale intensive production. Pig production expanded with the development of rail and road transport serving a predominantly (98 percent) domestic market.<sup>90</sup>

The efficiency of the low-input scavenging management system, with some supplements mainly to ensure pigs could be caught by owners, was poorly appreciated when the modern industry was created from the 1950s. Just as government programs focused on beef and dairy cattle upgrading to European breeds without an understanding of the advantages of domestic breeds, so the imported pig lines displaced the naturalised pig. USA, Germany, Denmark, Switzerland, and Australia were the source of genetic material of the Large White, Hampshire, and Duroc-Jersey breeds. A standard three-way cross system was introduced and gradually extended to farmers who, in so modernising, became committed to intensive pig raising, purchasing of feed stuffs and medicines, and production for regular sale.

A more than three-fold expansion<sup>91</sup> in the number of pigs officially

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<sup>84</sup> Posri, Sangwien., Falvey, L. and Hengmichai, Prakob. (1978)

<sup>85</sup> Visitpanich, Theera and Falvey, L. (1979)

<sup>86</sup> Falvey, L. and Visitpanich, Theera (1980b)

<sup>87</sup> Falvey, L. and Visitpanich, Theera (1980c)

<sup>88</sup> Falvey, L. (1981d)

<sup>89</sup> Credner, W. (1966)

<sup>90</sup> Donner, W. (1978)

<sup>91</sup> Ministry of Agriculture (1965)

slaughtered in Bangkok between 1947 and 1965 coincides with a rise in preference for imported breeds. Within less than thirty years, the 1965 production figure of 614,000 pigs per year rose some fourteen times to 8.7 million through the emergence of agribusiness and contract farming in association with feed millers, particularly the multi-national company Charoen Pokaphand. However, comparability of statistics is problematic. Even today, unofficial pig slaughter and roadside sale of meat is evident throughout the country, suggesting that statistics prior to 1965 which referred only to pigs officially slaughtered in Bangkok, reflect but a fraction of national production.

In 1978, 86 percent of pigs were raised in backyard enterprises with only four percent of producers maintaining more than 110 head. Medium to large scale producers were concentrated around Bangkok, the major market and were based on three-way cross lines where feed conversion efficiencies reached 3.0:1; backyard producers tolerated feed conversion ratios of up to 5:1. Slaughtering took place in modern abattoirs, municipal slaughterhouses, and simple local government slaughterhouses, although backyard slaughtering remained popular. Processing into hams, bacon, roast pork, and sausages involved many small processors, dominated by the Belucky LP group which controlled about half of the market share.<sup>92</sup> Export of live and frozen pigs and piglets was mainly undertaken by groups such as Charoen Pokaphand, which was not yet the dominant pig producer. Late 1970s' margins as a proportion of retail pork price were; 10 percent for pig growers, 2.1 percent for live pig wholesalers, 9.2 percent for carcass wholesalers, 13.9 percent for retailers. The risks of production and price were allocated to the grower who received the lowest margin, thus suggesting one attraction of the contract systems attached to feed mills.

The number of commercial pig farms in 1993 was recorded as 3,652 of which some 13 percent had more than 1,000 head, nine percent between 500 and 1,000 head, 21 percent between 200 and 500 head, 20 percent between 100 and 200 head, 27 percent between 50 and 100 head and 10 percent between 10 and 50 head.<sup>93</sup>

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<sup>92</sup> Valentine, Laurie and Davies Pty Ltd (1981)

<sup>93</sup> Department of Livestock Development (1994)

Since 1993, pig production has continued to rise by an average of four percent per year to a 1998 total of some 10.6 million head. The majority of pigs in 1996 were raised in the Central Plain (42 percent) with the North and Northeast having similar proportions (23 percent each). The most populous pig provinces in 1996 were Nakhon Ratchasima, Buriram, Ubon Ratchatani, and Sisaket, all in the Northeast.<sup>94</sup> Vaccination of pigs over the period 1987 to 1996 has increased some three-and-one half times from 1.5 to 5.2 million head.<sup>95</sup> The numbers and production of pigs from 1994 to 1996 is presented in Table 9.6.

**Table 9.6** *Production and Numbers of Pigs for each Region, 1994 – 1996 (million head)*<sup>96</sup>

Region	Number of Pigs			Pig Production		
	1994	1995	1996	1994	1995	1996
Northeast	1.3	1.3	1.4	2.1	2.1	2.1
North	1.3	1.2	1.4	1.8	1.8	1.9
Central	2.1	2.1	2.5	4.9	4.9	5.2
South	0.8	0.7	0.8	1.0	1.0	1.0
Whole Kingdom	5.4	5.4	6.1	9.9	9.8	10.2

The success of the intensive pig industry in Thailand has increased the risk of pig to human disease transfer to potentially higher levels than in many western pig producing countries. The spreading of a virus from pigs to humans in Malaysia in 1999, assisted by rapid news coverage, which led to slaughter and disposal of around one million pigs after the death of more than 100 persons is apposite. Thailand has irreversibly committed itself to modern intensive pig production in a manner similar to its industrial chicken industry, and is thereby reaping economic benefits while unwittingly introducing higher levels of moral hazard associated with human health and environmental risks.

The strength of developing the monogastric industries has been availability of high quality feeds from domestic agriculture and agribusiness. High levels of domestic demand for Western-style pig meat and reduction in demand for pig fat have been met through the modern industry's expansion. The 1997 Asian economic crisis affected livestock feed-poor countries and thereby highlighted the comparative

<sup>94</sup> Office of Agricultural Economics (1998)

<sup>95</sup> Department of Livestock Development (1997)

<sup>96</sup> Ministry of Agriculture (1998)

advantage of Thailand in this competitive and low margin industry. Intensive pig production based on imported feeds is easily rendered unviable by exchange rate fluctuations. In Thailand, responsibility in waste management and utilisation and treatment of waste water are now major management issues. With a farm value of 40 billion baht in 1996, second only to poultry in the land-based livestock sub-sector, pig production ranks fifth ahead of maize in terms of value received by Thai farmers.<sup>97</sup>

## **Poultry**

Possibly the homeland of the ancestors of today's domestic chickens, Thailand has developed into one of the world's large poultry producers. First domesticated<sup>98</sup> through providing feed to wild birds and progressively favouring those individuals with limited flight ability, chickens raised by ancestors of the Thai allowed the basis for successive technological developments in poultry raising. This led to chickens, ducks and, to a minor extent other poultry, being associated with the ecology of Tai and other villages. Poultry was raised as a source of protein to complement the predominantly fish and rice diet, and assumed importance in animistic rituals. Each household had poultry which survived predominantly on feed scavenged around the village and surrounding forest with occasional rewards of kitchen scraps, mainly as a means of maintaining some identity between birds and owner. More than a millennia ago, fighting cocks were apparently valued in the advanced and Indianised centre of Nakorn Si Thammarat, as indicated in a statue of that era; cockfighting had long been codified as a wordly art in India by this time.<sup>99</sup>

Until Chinese immigration, ducks had simply been mixed in with chickens, with the only separation being the preference of ducks for wetter regimes around a village. A separation between large ducks flocks raised by Chinese, and a preference for chickens among village Thai, favoured a duck industry over chicken industry due to Thai reluctance to kill chickens. As recently as the 1970s, chickens raised around Thai villages provided low levels of production from large numbers

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<sup>97</sup> Ministry of Agriculture (1998)

<sup>98</sup> Andrews, J.M. (1935)

<sup>99</sup> Burton, R. and Arbuthnot, F.F. (1963)

necessary to withstand epidemic diseases and attacks by predators in a system which many consider inefficient.

Low consumption of meat and eggs among Thai farmers is also indicated in the sales of chickens and eggs to Chinese and wealthier townspeople. A survey in the 1930s indicated that the average Thai family consumed less than three chickens and 24 eggs per year;<sup>100</sup> consumption may not have increased substantially, even by the 1970s.<sup>101</sup>

The rapid and successful development of a modern poultry industry in Thailand occurred through the combination of agribusiness development and favourable government policies. Policies allowed Chinese-Thai agribusiness houses to become established under protected conditions with guaranteed access to critical resources. The broiler industry exemplifies the success of Thai agribusiness through the development of Charoen Pokaphand as a feed milling company extending into the poultry industry through contract farming based on monopolistic supply of highly bred chickens from the USA.

The export of chicken meat from Thailand expanded rapidly (Figure 9.1) creating demand for maize such that maize exports declined from 2.2 million ton or 45 percent of total production in 1980, to 1.2 million ton or about 20 percent of production in 1989. Expansion in maize production through the 1960s and 1970s was hardly related to this later demand; by the time the chicken industry was a major force, areas suited to maize production had largely been exploited. No importation of maize occurred through this period due to high tariffs; with their reduction from six percent to 0.6 percent in 1992, some 250,000 ton was imported within one year. Nevertheless, Thailand remained a net exporter of maize at that time.<sup>102</sup>

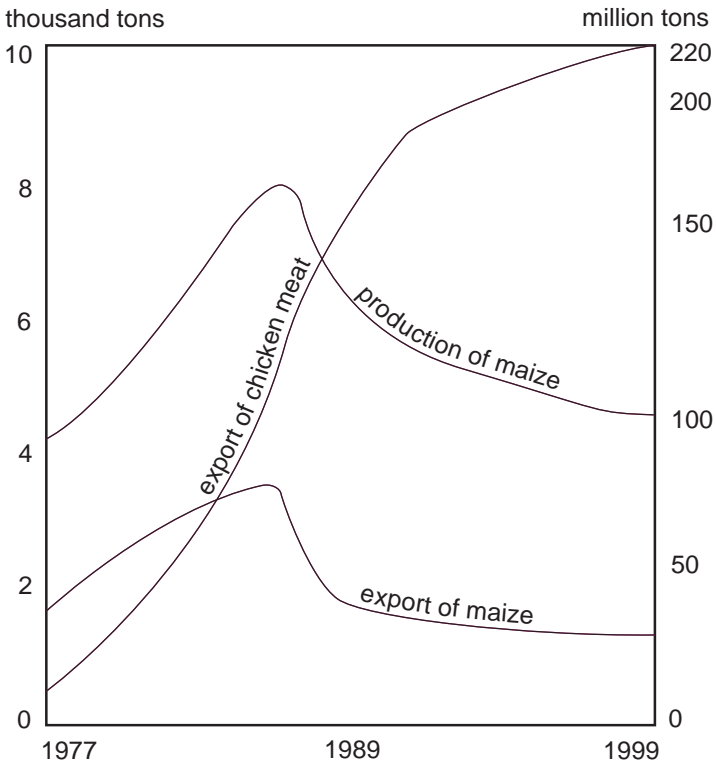
Chicken farms include backyard, independent commercial, and contract farms. Backyard growers continue to each raise around ten native chickens for home consumption and occasional sale from eggs and birds, and also for cock

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<sup>100</sup> Zimmerman, C. (1931)

<sup>101</sup> Donner, W. (1978)

<sup>102</sup> Siamwalla, Ammar (1992)



**Figure 9.1** Export of Chicken Meat Compared to Maize Production and Export<sup>103</sup>

fighting. Native breeds such as *Kai Ooh* and *Kai Tapao*<sup>104</sup> roam the house-yard requiring low labour inputs. Independent commercial growers follow modern management techniques and, often from prior contract-growing experience control their own marketing, and in assuming greater risk, attract higher potential rewards than contract farmers. Economies of scale appear to be reducing the proportion of independent growers. Contract farming includes price guarantees, flat price contracts, and open account contracts; growers generally receive inputs in exchange for a guaranteed price. Dating from the mid-1960s, contracts became popular only after the introduction of price guarantees in the mid-1970s; by the 1980s, more than 99 percent of intensive growers were contracted and were located close

<sup>103</sup> Siamwalla, Ammar (1992) and Customs Department

<sup>104</sup> Chantalakhana, Charan (1981)

to Bangkok.

Purchasing, feed stuffs, medicines, and imported breed stock (Figure 9.2), the contract grower provides labour and skill to produce broilers on behalf of integrated feed mill, slaughterhouse, and processing firms.<sup>105</sup> Contracts vary from open accounts for feed inputs and interest against chicken sales, to being essentially payment for wages to manage an enterprise.<sup>106</sup> Sale price guarantees which shift the risk of growth rates, disease and input costs to the producer have been preferred by chicken processing firms, including Bangkok Livestock Trading Company (Charoen Pokaphand), Saha Farm, and Srithai Livestock Company. More recent piece-rate contracts with profit shares and incentive payments, in some cases including loans to build chicken houses, follow a USA system of Charoen Pokaphand's partner Arbor Acres.<sup>107</sup> Contract farming has allowed Charoen Pokaphand to replace the USA as the leading supplier of broilers to Japan, and to pioneer one approach to allow small-holders to remain on their land.<sup>108</sup>

From hand processing of unevicerated carcasses with heads and feet attached, integration of major groups involved in the six major stages of chicken production and marketing (Table 9.10) has produced, for example, the second largest company within the CP Group, the Bangkok Livestock Trading Company, which processes more than 100,000 chickens per day.

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<sup>105</sup> Paopongsakorn, Nipon (1985)

<sup>106</sup> Manarangsang, Sompop (1992)

<sup>107</sup> Pipatkusolsook, Preecha (1982)

<sup>108</sup> Bello, W., Cunningham, S. and Kheng Poh, L. (1998)

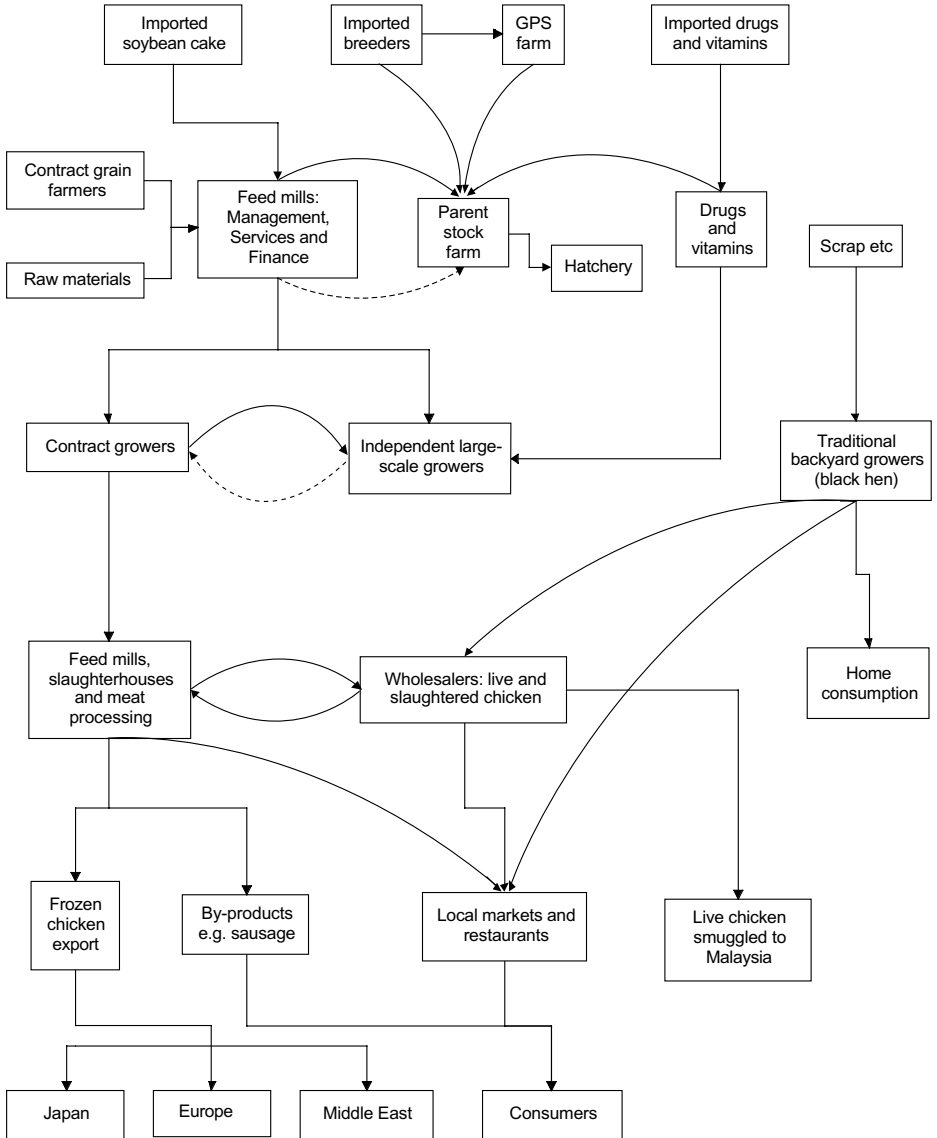


Figure 9.2 Inputs and Outputs in the Commercial Thai Chicken Industry<sup>109</sup>

<sup>109</sup> Paopongsakorn, Nipon (1985)

**Table 9.10** Vertical Integration in the Thai Chicken Industry<sup>110</sup>

Activities	Firms	Share (%)	Year
Day-old chicks hatchery	<ul style="list-style-type: none"> <li>• CP and its members</li> <li>• Seven firms: CP, Laemthong, Centago, Thai Feed Mill Industry Sri Thai and P. Charoenphan</li> </ul>	40-50	1981
Animal Feeds	<ul style="list-style-type: none"> <li>• CP and its subsidiaries</li> <li>• Eight firms: CP, Laemthong, Centago, Betagro, Krung Thai, Sri Thai, Laemthong Kaset, Inter Industry Trade</li> </ul>	33-40 70-80	1980 1980
Drugs, vitamins, premix	<ul style="list-style-type: none"> <li>• CP (Advanced Pharma), May &amp; Baker, Diethelm, Wellknow, Pfizer, Thai Pharmi, etc</li> </ul>	n.a.	-
Broiler farm	<ul style="list-style-type: none"> <li>• CP and its contractors</li> <li>• Nine farms: CP Betagro, Centago, Sri Thai, Laemthong, First Farm, P. Charoenphan, Krung Thai, Saha Farm</li> </ul>	26-30 65-70	1980-81 1980-81
Chicken trading (live and slaughtered) in Bangkok	<ul style="list-style-type: none"> <li>• CP</li> <li>• Six firms: CP, Saha Farm, Centago, Betagro, Sri Thai</li> <li>• Wholesalers at Klongton</li> </ul>	40-50 80-90	1981 1981
Export	<ul style="list-style-type: none"> <li>• CP (Bangkok Livestock Trading)</li> <li>• Saha Farm</li> <li>• Laemthong</li> <li>• Centago</li> </ul>	38.9 32.4 19.5 9.2	1980

Board of Investment promotion of chicken slaughterhouses has ensured capital intensive modern facilities suited to export production, particularly for Japan. Large growers, traders and processors are committed to technological and management advances, including in-house research, linkages to the Department of Livestock Development, and strategic joint venturing with foreign partners. Size enables weathering of low international prices or other crises, such as epidemics, which often force smaller scale producers out of the industry or into contract growing.

Chicken exports rose from a 1973 total of 142 ton at more than 60 percent per annum into the 1980s until Thailand supplied 26 percent of the Japanese market in the form of; boneless breasts, boneless leg fillets, skinless boneless breast, wing

<sup>110</sup> Paopongsakorn, Nipon (1980)

sticks, and bone-in leg products with assistance through strategic links to major Japanese trading firms including Marubeni and Itoman. Such success includes certain continuing risks, including:

- dependence on imported technology
- reliance on joint venture arrangements for technology, management, and markets
- uncertain sustainability of low returns to agricultural producers
- reliance on imported soya bean meal
- governmental taxes including inspection service costs
- processing plant supervision for night operations with high labour turnover
- transportation risks to slaughterhouses.<sup>111</sup>

By 1997, animal products, the majority of which were derived from chicken, represented the third largest agricultural export from Thailand.<sup>112</sup> Within the 1997 the export value of animal products of 30.3 billion baht, poultry exports were:

Fresh Chilled Frozen Meat	11.0 billion baht
Duck Meat	0.3 billion baht
Other Fresh Chilled Frozen Poultry	0.08 billion baht
Eggs	0.1 billion baht
Swallow's Nests	0.04 billion baht

Poultry export as live animals contributed a further 70 million baht in 1997. The numbers of chickens and ducks has risen over the past decade in response to rises in the price per animal and egg prices. Over the period 1987 to 1986 (Table 9.11), chicken numbers rose from some 84 billion by nearly 100 percent, while duck numbers rose from 16 billion birds by around 40 percent. Numbers of geese appear to have remained relatively stable.

<sup>111</sup> Paopongsakorn, Nipon (1985)

<sup>112</sup> Office of Agricultural Economics (1998)

**Table 9.11** Poultry Numbers ('000) and Farm Prices (bt/kg; bt/1000) , 1987-1996<sup>113</sup>

Year	Number on Farms			Farm Price			
	Chicken	Duck	Geese	Live Chicken	Live Duck	Chicken Eggs	Duck Eggs
1987	84,495	15,620	433	19.15	19.82	1,050.00	1,180.00
1988	93,134	15,934	642	19.49	24.21	1,250.00	1,490.00
1989	102,343	16,683	427	20.66	35.16	1,280.00	1,550.00
1990	117,647	17,902	519	23.12	37.74	1,380.00	1,620.00
1991	126,609	19,124	536	22.44	32.04	1,370.00	1,630.00
1992	137,386	19,345	440	22.02	31.23	1,300.00	1,540.00
1993	139,085	21,778	548	22.85	32.54	1,400.00	1,620.00
1994	147,092	21,812	460	25.19	37.16	1,320.00	1,660.00
1995	148,784	18,897	413	27.96	33.92	1,470.00	1,710.00
1996	160,789	21,400	-	26.79	41.47	1,610.00	1,870.00

Production of broilers and hen eggs over the period 1992 to 1998 indicates rises of 10 percent and 14 percent respectively (Table 9.12).

**Table 9.12** Millions of Broilers and Billions of Hen Eggs, 1992 - 1998

Year	Broilers	Hen Eggs
1992	723.3	8.1
1993	725.8	7.3
1994	679.8	8.0
1995	700.0	8.3
1996	718.8	8.6
1997	753.5	9.0
1998	798.3	9.2

The majority of chickens (48 percent) and ducks (56 percent) are raised in the Central Plain; the next largest production area is the Northeast, associated with the higher human population, which supports 23 percent of chickens and 31 percent of ducks respectively. The intensive broiler industry is concentrated (75 percent) in the Central Plain as indicated in Table 9.13, notwithstanding a different distribution for overall poultry numbers. The difference is partly due to the raising of native chickens which, while developing some boutique high-priced outlets in Bangkok, remains primarily a locally traded and consumed product.

<sup>113</sup> Office of Agricultural Economics (1998)

**Table 9.13** Production of Broilers and Native Chickens by Region, 1994 - 1996<sup>114</sup>

Region	Number of Birds					
	Broiler			Native Chicken		
	1994	1995	1996	1994	1995	1996
Kingdom	679,798,094	699,875,927	718,836,830	73,978,956	82,154,416	89,878,324
Northeast	66,118,197	67,972,912	62,988,977	32,425,890	36,320,687	39,455,472
North	59,174,122	60,825,080	55,594,755	25,632,785	28,051,308	30,034,879
Central	494,240,858	509,597,766	540,673,299	9,432,350	10,571,566	12,046,582
South	60,264,917	61,480,169	9,579,799	6,487,931	7,210,855	8,341,391

### Aquatic Animals

The traditional association of fish and rice in Thai culture is coincidentally evident in the importance of these commodities to modern-day Thailand. Today's fisheries production bears as little relationship to the fish in Sukhothai waters as does the high-input rice crop to the rices of the Sukhothai fields.<sup>115</sup> Freshwater, marine, and brackish shrimp culture fisheries provides around 35 percent of animal protein in the Thai diet,<sup>116</sup> a significant component of export income, and is an important part of the domestic economy. The Ramkhamhaeng Inscription also bespoke a balanced ecosystem where fish co-existed with rice in paddy fields, a situation less evident in modern Thailand. Over-fishing, changed environments, and higher human population density has now outstripped the ecosystem's ability to provide the low-cost subsistence animal protein which fuelled the building of a Thai civilisation.

Asia is the world's main producer of fish.<sup>117</sup> Thailand is the fifth largest producer in Asia behind China, Japan, India, and Indonesia, and is eighth in the world, the USA, Peru, and Russian Federation also being larger producers. Sophisticated catching and farming techniques introduced in recent decades have been underpinned by continuing rises in fish prices, unlike other agricultural products.<sup>118</sup>

<sup>114</sup> Office of Agricultural Economics (1998)

<sup>115</sup> Wyatt, D.W. (1988)

<sup>116</sup> Williams, M. (1999)

<sup>117</sup> ICLARM (1999)

<sup>118</sup> Williams, M. (1999)

The motorised fisheries boom of the 1960s based on demersal or seabed fishing replaced the traditional bamboo-stake system.<sup>119</sup> Unregulated use of such efficient capture techniques led to rapid exploitation of fisheries resources which spurred the Thai fishing fleet to expand its area of coverage, which was only curbed by the introduction of the 200 mile economic zone agreements of the 1970s. Similarly, inland fisheries faced exhaustion of naturally available resources which in turn spurred the development of aquaculture, initially developed around catfish and later, fresh water shrimps. Marine aquaculture of tiger prawns along coastal areas destroyed mangrove forests as it captured high priced foreign export markets.<sup>120</sup>

## Freshwater

Tradition pervades fisheries as agriculture, albeit in the shadow of export fisheries industry techniques. Freshwater fishing continues to include village level crafts proudly executed during the agricultural off-season. Communal harvesting of freshwater fish, once socially efficient, has contributed to over-exploitation as the human population rose. Aiming to regenerate freshwater fish species from the 1970s, government stations produced some five million fry for annual distribution and release into public waterways. As native stocks failed to meet demand and tastes of immigrants, freshwater fish culture expanded from the opportunistic cultural systems of Khmer barai.

Fish culture technology has changed through the twentieth century from pond culture probably introduced around 1915 by Chinese immigrants to farm the Common Carp (*Cyprinus carpio*), and later other Chinese Carp. A small-scale activity around Bangkok, the technology evolved by the 1950s into small farmer constructed ponds which borrowed from Chinese-style ponds and traditional Thai trapping ponds. Ponds were constructed beside streams and canals to allow fish to migrate naturally during periods of flooding, and after being allowed to grow for three months or so, caught in simple nets across draining ponds.

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<sup>119</sup> Arbhahhira, Anat et al (1987)

<sup>120</sup> Siamwalla, Ammar (no date)

The introduction of Tilapia (*Tilapia mossambica*) in 1951, with assistance from the United Nations' Food and Agriculture Organisation to construct some 15,000 ponds, led to a rapid shift to a new staple fish. Expansion of fish culture employed sociological understanding of traditional farming systems and thus belied the adage that traditional Thai agricultural industries are the most difficult to change. However, swamp-land conversion to ponds is now considered as one of agriculture's environmental imposts.

The high reproductive and growth levels of Tilapia, its suitability to both fresh and brackish waters, and its palatability as a table fish, led to widespread cultivation in Thailand, as in many countries. Within the 1950s, it was raised in all provinces of Thailand and was especially important away from the sea and major rivers; yields averaged nearly 3.2 ton per rai (20 ton per hectare). At this time of rapid expansion of the cultured fish industry of Thailand, it was estimated that the area suitable for fish culture was in the order of 3.6 million rai (575,000 hectare) of which only some 10 percent had then been developed.<sup>121</sup>

Official introductions of exotic fish species were apparently limited to the Tilapia, and Common and Chinese Carps, from Penang and Hong Kong respectively in 1948, ignoring earlier introductions and other species brought with immigrants. Government-owned fish ponds numbered 625 compared to 12,619 private ponds in 1967 with a combined surface area of seven square kilometre, mainly (44 percent) in the drier Northeast. Irrigation storages served as fish breeding units to further supplement freshwater fish supplies.<sup>122</sup>

Ponds provided alternative, rather than complimentary, freshwater fish, as native habitats declined and as introduced species dominated the newly created aquatic environments. Annual catches in the early 1950s of the order of 54,000 ton rose to 91,000 ton by the late 1960s, 60 percent of which was from the Central Plain and 33 percent from the Northeast.<sup>123</sup> However, fisheries statistics are unreliable due to the rapid and local consumption of fish and their association with traditional diets in rural areas.<sup>124</sup>

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<sup>121</sup> Pongsuwana, Ubol (1955)

<sup>122</sup> Donner, W. (1978)

<sup>123</sup> Donner, W. (1978)

<sup>124</sup> Ministry of Agriculture (1961)

Inland fishing along rivers, canals, swamps, and lakes, was traditionally based on bag nets, seines and gill nets, cast nets, dip nets, scoop nets, traps, baskets, lines, and spears. Natural narrow sections of watercourses, enhanced by creating small gateways, evolved into systems associated with drainage of specially created fish ponds. Production of traditional systems declined as agricultural intensification, including ponds, advanced; catches of small cyprinid fish, once numbered in the millions, today yield far less than those remembered by old folk. Before the 1950s, local markets were well supplied with fish through river transport associated with rice collection and distribution. The major freshwater fish, according to historic reports, appear to have been Serpent Heads, Climbing Perch, Feather Back, and Catfish.

Fish culture in Thailand recognises four reproductive variations:

- native fish which can reproduce under cultured conditions
- native fish unable to spawn in ponds, requiring fry and fingerlings collection from natural waters
- introduced fish able to reproduce under cultured conditions
- introduced species unable to reproduce in ponds requiring fry and fingerlings to be imported.

These categories continue to dominate fish culture, although research outcomes have enabled local breeding of lines capable of spawning in cultured conditions, as well as enhanced exotic fish adaptation to local conditions, while also improving growth rates.

## **Marine**

Marine fisheries has been practised along all parts of the long Thailand coast. Based on stake traps and sea vessels, over-exploitation of the fish resource was protected by technological limitations until recent decades. The stake trap used timber poles driven into the sea bottom to form circular enclosures with long wings of bamboo or wooden poles to intercept fish and direct them into the trap. Thousands of such traps once operated, in some cases appearing to cover the whole surface area of the extensive Songkhla Lakes, although these were initially aimed at shrimp capture. Utilised in water up to 20 metres in depth, traps require strong construction to withstand wave and current actions, and hence require significant investment. In recent years, financial returns from traps have been dependant on

the availability of the Little Mackerel (*Rastrelliger*) which is consumed widely in Thailand. Nets constructed across river mouths, while used periodically, have been outlawed.

Thai fishing boats were motorised from the 1950s thereby allowing the use of other mechanical devices. Thus began an era of increased fish extraction which led to over-fishing of the Gulf of Thailand. From a slow beginning in collecting fisheries statistics in the 1950s by net sampling procedures, regulations to limit catches were promulgated which, appear to be taking effect in the 1990s.

Handling and processing of fish has similarly changed from traditional practices into a sophisticated industry. Fish which can be traded fresh, are packed in ice before boats dock and maintained in-ice through to final marketing throughout the country. Processed fish are dried, salted, smoked, cooked for preservation, and made into paste, meal, liver oil, cakes, crackers, and fish sauces. Fermented fish, a traditional Tai product made from freshwater fish is still appreciated in the Northeast and North, and is seen as having further market potential. Canning of fish products for human and pet consumption attracted foreign investment through such companies as Safcol, and introduced new canning concepts to Thailand. Meal from waste fish similarly stimulated the agribusiness expansion into animal feeds.

Marine fishing value increased by more than 1,000 percent during the 1960s with the introduction of motorised vessels, modern catching equipment, and structural change in the industry as small simple fisherman withdrew. Taxing of catches proved difficult with such rapid changes, while government taxation on traditional marine fishing systems continued, raising an annual revenue of only some 9 million baht.<sup>125</sup> Marine fisheries production increased from the 1950s catches of 143,000 ton to 907,000 ton by the late 1960s.

### **Brackish Waters and Shrimp Culture**

Culture of fish in brackish water required widespread destruction of mangrove areas to create a financially successful yet environmentally unsustainable Black Tiger Prawn industry. Other brackish water fish cultivation is based on Sea

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<sup>125</sup> NSO (1967)

Bass, Milk Fish, and Molluscs.<sup>126</sup> Sea Bass (*Lates calcarifer*), one of Thailand's best eating fish, was traditionally sourced from estuaries around the Gulf of Thailand. Under cultured conditions, young Sea Bass of less than 20 centimetres are collected for culturing in ponds or wooden enclosures, and fed small fish and shrimps until they attain market size. Prescriptive feeding and use of enclosed cages in natural brackish waters have advanced the industry in recent years. Milk Fish (*Chanos chanos*) production, based on fry and fingerling collection from tidal streams and backwaters on both sides of the Gulf, has borrowed technology from Indonesia and the Philippines. Mollusc culture was based on the Sea Mussel (*Mytilus smaragkinus*) in estuarine areas in muddy flats until oyster production assumed importance in the 1970s.

A long-term supplement to the diets of coastal Thai people, shrimp cultivation began with extensive ponds tended on a seasonal basis, probably with minimal environmental impact.<sup>127</sup> Of the various shrimp species naturally found in Thai waters, Banana, School, and in particular Black Tiger Prawn, proved the most popular for culture as catches declined through the 1970s.<sup>128</sup>

Thailand became the largest producer and exporter of Black Tiger shrimp (*Penaeus monodon*) from 1992, subsequently rising to produce almost twice that of the second highest producer, Indonesia. The coastal areas of Thailand suited development of artificial habitats for shrimp aquaculture<sup>129</sup> and unregulated mangrove destruction allowed rapid industry development.<sup>130</sup> Shrimp capture which formed 90 percent of national production in 1975 declined to 25 percent within two decades, with the greatest expansion of aquaculture being in the eastern region, followed by the south, west, mid-gulf and inner-gulf regions.<sup>131</sup>

By 1995, almost the whole coastline suited to shrimp production had been developed for aquaculture.<sup>132</sup> Research focused less on environmental concerns than production problems<sup>133</sup> to justify the high capital and low land and

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<sup>126</sup> Ministry of Agriculture (1961)

<sup>127</sup> Wilks, A. (1995)

<sup>128</sup> Gronski, R.T. (1997)

<sup>129</sup> Csavas, I. (1994)

<sup>130</sup> Bailey, C. and Skladany, M. (1991)

<sup>131</sup> Department of Fisheries (1995)

<sup>132</sup> Flaherty, M. and Karnjanakesorn, Choomjet (1995)

<sup>133</sup> NACA (1995)

labour intensities of the industry.<sup>134</sup> Just as rice production has irreversibly changed the natural environment of Thailand and created a potentially socially and environmentally sustainable system suited to natural seasonal rhythms, one hopes that current prescriptive approach to shrimp culture<sup>135</sup> evolves to more sustainable system.

Intensity of production increased through the 1980s, ostensibly to protect remaining mangrove areas, although the greater concentration of waste introduced a new environmental burden.<sup>136</sup> At the same time, policies to facilitate foreign exchange earnings encouraged contract farming systems akin to the poultry industry. From initial investment with World Bank and Asian Development Bank assistance,<sup>137</sup> the industry rapidly became dominated by multinational and national private sector interests.<sup>138</sup> The fifth and sixth Plans specifically promoted shrimp aquaculture; the first multinational company, Cargill, entered the Thai industry in the late 1980s. Small-holder shrimp growers were encouraged, through BAAC and private bank loans, to associate with agribusiness groups such as CP Feedmill and Aquastar,<sup>139</sup> and continued World Bank support was justified as assisting small-holders to access new technologies, quality control, and marketing services.<sup>140</sup>

Two agribusiness groups came to dominate shrimp aquaculture, Aquastar Limited and CP Aquaculture Business. Aquastar initially strived to integrate social, development, economic, and environmental principles, while CP used a vertically integrated approach similar to its poultry business. Beginning with a demonstration farm, Aquastar worked with individual land holders and provided extension services. Rapid expansion led to an agreement with Bechtel Engineering for large scale expansion of a standard pond design, with Aquastar providing larvae, feed, and marketing. BP Nutrition acquired Aquastar thereby linking it to wider international marketing resources which also introduced monitoring procedures aimed at increasing aquaculture water quality, with some environmental benefit.

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<sup>134</sup> Pathranarakul, Pairote (1995)

<sup>135</sup> Norgaard, R.B. (1994 )

<sup>136</sup> Panyotou, T. and Sussengkarn, Chalongphob (1992)

<sup>137</sup> Skladany, M. and Harris, C. (1995)

<sup>138</sup> USDC (1992)

<sup>139</sup> Gronski, R.T. (1997)

<sup>140</sup> Glover, D. J. and Kusterer, K.C. (1990)

CP Aquaculture business was the fastest growing division of the massive agribusiness conglomerate CP Group through the last decade, as it expanded shrimp aquaculture into China, Indonesia, India, Vietnam, Mexico, and Australia. Overtly oriented to vertical integration, and high efficiencies, CP expanded shrimp production rapidly from 1990, utilising products from its feed mills, and marketing product through its continually expanding food market network. With land resources of between 2,000 and 5,000 coastal hectare, contract farming operations link with company operations in a manner which minimises overhead costs while reliably producing an export quality product. The CP Group also processes shrimp through four facilities in Thailand and two in Indonesia and, prior to the Asian economic crisis, was engaged in negotiations for access to other Asian coastlines.<sup>141</sup>

Shrimp aquaculture technology rapidly exceeded human management capabilities within the ecosystem. Prescriptive chemical treatment of ponds eliminated organisms which consumed residual feed and waste, thereby allowing accumulation until algal blooms utilising these nutrients, consumed available oxygen, thereby reducing water quality and weakening shrimp to virus attack. Tidal water exchange, once used in extensive ponds to manage water quality, is of limited long term utility in such an intensive system and ponds have been readily abandoned for new areas in a form of shifting aqua-cultivation.<sup>142</sup>

## **Fish Production**

In the 1960s, marine and freshwater fish were consumed fresh (70 percent), dried (10 percent), boiled, or smoked (four percent) with the balance processed into paste, fish sauce, meal, fertiliser or fermented.<sup>143</sup> Calculation of the average production through the decade of the 1960s suggests that some 15,000 ton of fish and products were exported while some 9,000 ton valued at 50 million baht per annum were imported.<sup>144</sup>

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<sup>141</sup> Gronski, R.T. (1997)

<sup>142</sup> Weber, M.L. (1996)

<sup>143</sup> Department of Fisheries (1969)

<sup>144</sup> Donner, W. (1978)

By 1985 - 1994, catches and production of marine and freshwater fish (Table 9.14) had risen by 140 percent for freshwater production and more than 400 percent for marine capture. Major production in 1994 was of; Tilapia, Local Carp, Catfish, Snake (Serpent) head, Sepat Siam, and Prawns (*Macrobracium*). For marine fish, major production was of; Jumbo Tiger Prawn, Anchovy, Sardines, Indo-Pacific Mackerel, Jelly Fish, Bonito, Thread-Fin Bream, Scad, Squid, miscellaneous Shrimp, Green Mussel, Trevally, and Indian Mackerel.<sup>145</sup>

**Table 9.14** Quantity and Value of Marine and Freshwater Fish, 1985 - 1994<sup>146</sup>

Year	Freshwater Fisheries ('000 ton)		Marine Fisheries (million baht)	
	Quantity	Value	Quantity	Value
1985	167	4,134	2,058	15,650
1986	188	4,004	2,349	18,877
1987	177	4,558	2,602	23,083
1988	184	4,382	2,446	28,039
1989	201	4,441	2,539	31,428
1990	231	5,903	2,555	35,492
1991	259	6,260	2,709	46,765
1992	274	6,477	2,966	59,067
1993	337	8,579	3,048	69,827
1994	373	9,702	3,150	77,299

The decade 1986 - 1995 substantiated dominance of pond culture over paddy field fish, ditch, and cage culture. Areas for cultured fish (Table 9.15) rose by some 2.7 times for ponds; numbers of farms with ponds increased by more than three-fold, while paddy field culture increased marginally, a trend consistent with the number of culture units. The value of fish from pond culture in 1995 was 4.4 billion baht, from paddy culture was 0.9 billion baht, and from ditch and cage culture was 32 and 19 million baht respectively.<sup>147</sup>

<sup>145</sup> Department of Fisheries (1996)

<sup>146</sup> Department of Fisheries (1996)

<sup>147</sup> Department of Fisheries (1996)

**Table 9.15** Area (ha) of Freshwater Fisheries Cultural Systems, 1986 - 1995<sup>148</sup>

Year	Pond Culture	Paddy Culture	Ditch Culture	Cage Culture
1986	90,691	149,011	1,443	24
1987	146,881	147,025	1,178	31
1988	143,460	141,492	1,556	36
1989	117,583	141,678	918	54
1990	115,371	140,657	1,168	74
1991	125,698	140,096	729	29
1992	158,468	148,589	1,054	24
1993	178,011	153,243	1,435	87
1994	191,934	169,358	3,711	10
1995	247,292	112,258	5,421	22

Inland fisheries stations produced fish fry and other aquatic animals to a total number of more than 350 billion units in 1994, dominated by Thai Silver Carp, Small Scale Mud Carp, Giant Fresh Water Prawn, Cinnib Caro, Nile Tilapia, and Rohu. Overall production of freshwater fisheries was highest for Local Carp (19,000 tons), Tilapia (15,000 tons) and Snake-head (11,000 tons), although in terms of value, Snake-head ranked ahead of Local Carp and Tilapia. Notwithstanding the sophistication of the modern fisheries industries, official fish catch and raising figures may be underestimated by up to 30 percent as a result of subsistence use.<sup>149</sup> The role of small-scale fishers and fish production in integrated farms is thus easily neglected in development planning.

## Goats, Sheep and Elephants

Goats, and to a lesser extent sheep, form part of the undeveloped genetic resources of Thailand.<sup>150</sup> Production in the North suggested the superiority of goats to sheep,<sup>151</sup> although greater potential exist in the South where Muslim communities raise as many goats as large ruminants.<sup>152</sup> Interpolations indicate that some 2,000 goats are imported from Myanmar each month,<sup>153</sup> and that imported goat meat volume has been rising at about 12 percent per year.<sup>154</sup> Census

<sup>148</sup> Department of Fisheries (1996)

<sup>149</sup> Williams, M. (1999)

<sup>150</sup> Falvey, L. (1977a)

<sup>151</sup> Falvey, L. (1977b)

<sup>152</sup> Saitanoo, Somkiat (1985)

<sup>153</sup> Saitanoo, Somkiat., Cheva-Isarakul, B. and Bichaironarongsongkram, K. (1991)

<sup>154</sup> FAO (1989)

inaccuracies<sup>155</sup> are indicated from this demand, and the biological capacity of around 38 percent increase per year from goats in the South, as well as unrecorded movement of goats and goat meat to Malaysia. Raised predominantly as a secondary activity to fishing, rice, oil palm, or fruit tree production, goats are mainly used for home consumption<sup>156</sup> from meat breeds.<sup>157</sup> Dairy goats form less than one percent of the population. Productivity potential can be improved by judicious cross-breeding, and improved health and nutrition, although the indigenous breed's suitability to village conditions favours its retention for most current purposes.

Deriving from Indian and Arabic sheep breeds which arrived in Thailand more than 5,000 years ago,<sup>158</sup> local types of Thai indigenous and Bangladesh-Burmese types<sup>159</sup> have been raised with limited success.<sup>160</sup> Mature weights of around 24 kg and growth rates of less than 55 gram per day under field grazing produces low meat yields<sup>161</sup> and coarse fibre, indicating unlikely prospects for development.

Thai working elephants<sup>162</sup> form part of a wider tradition of the regional colonial period of timber extraction as the Indian and Burmese commands used by Thai mahouts reflect.<sup>163</sup> A traditional regal and religious association with the elephant is also reflected in wider social empathy with individual elephants affected by over-stocking today. The Lampang Elephant Training School created by the Royal Forestry Department for a past era included medical care and welfare, functions now assumed by a non-government group. However, the size and digestive inefficiencies of large numbers of unemployed elephants suggest that unsustainable numbers exist. If forest areas are now less than 20 percent of those when elephant numbers were at their peak, and provided with special treatment for log extraction, then one might argue that today's stocking rate should be proportionally lower. Notwithstanding new roles in tourism, elephant welfare will include a realistic approach to the number of animals able to maintained in a comfortable state.

<sup>155</sup> Office of Agricultural Economics (1998)

<sup>156</sup> Saitanoo, Somkiat., Norton, B.W., Pattie, W.A., and Milton, J.T.B. (1991)

<sup>157</sup> Chantalakhana, Charan. (1990)

<sup>158</sup> Devendra (1975)

<sup>159</sup> Hoare et al (1976)

<sup>160</sup> Falvey, L. (1986b)

<sup>161</sup> Falvey, L. and Hengmichai, Prakob (1978)

<sup>162</sup> Falvey, L. (1983)

<sup>163</sup> Corvanich, A. (1976)

## The Future for Livestock

Livestock including fish production, once an integrated component of subsistence agriculture, is now also a specialised industry supplying modern animal products. Livestock and livestock product consumption (Table 9.16) is conservatively expected to rise 300 percent within 25 years especially in less developed countries. This will cause further intensification in Thailand with its comparative advantage in feed production, and probably polarise livestock industries between subsistence and commercial.

**Table 9.16** Ton of Meat Production Per Thousand Capita in Asia<sup>164</sup>

Country	Production	Production/ Capita	Annual Growth Rate (%)		
	1995	1995	1966-75	1976-85	1986-95
China	47,752,610	39.1	3.81	7.48	8.40
Japan	3,200,840	25.6	7.29	4.47	-0.78
Rep. of Korea	1,416,683	31.5	5.71	10.82	6.56
Mongolia	214,427	87.1	4.16	-0.13	-0.53
Cambodia	153,508	15.3	1.68	5.17	5.60
Indonesia	1,936,497	9.8	3.35	6.36	6.58
Lao-PDR	49,141	10.1	-3.42	6.60	3.24
Malaysia	956,259	47.5	6.74	5.49	8.21
Myanmar	335,467	7.4	3.92	4.48	0.73
Philippines	1,622,850	23.9	2.68	1.55	8.35
Singapore	147,872	44.4	8.76	1.40	1.20
<i>Thailand</i>	<i>1,473,500</i>	<i>25.3</i>	<i>4.66</i>	<i>4.91</i>	<i>3.16</i>
Vietnam	1,385,620	18.8	-0.20	7.12	4.72
Afghanistan	230,520	11.7	2.86	0.68	0.57
Bangladesh	370,837	3.1	1.72	0.80	3.55
Bhutan	7,764	4.4	2.48	3.50	1.71
India	4,391,485	4.7	2.15	3.18	3.55
Maldives	850	3.3	2.50	2.83	1.25
Nepal	204,648	9.5	3.60	4.99	2.07
Pakistan	1,856,250	13.6	3.32	5.17	6.73
Sri Lanka	88,108	4.9	1.12	-0.49	4.64

<sup>164</sup> Kaosaard, Mingsarn and Rerkasem, Benjawan (1990)

Consideration of the environmental costs of intensive animal industries, effects small-holder use of by-products, and benefits such as work, savings, and social status, indicate a continuing role of subsistence livestock production. Linking this to a semi-commercial production system, such as for cattle and buffalo in the Northeast, may well allow some small-holders to gain financial benefits. However, subsistence production systems are by definition unable to supply the product demanded by cities and export markets. Thus intensive livestock industries which use by-products of other agro-industries such as fish meal from the fisheries industry, palm oil cake from the oil palm industry, and brewers' waste from the brewing industry, will probably lead growth in agriculture in the next two decades.<sup>165</sup>

Except for fish, meat production statistics for the region do not yet indicate Thailand's comparative advantage. With increased demand for livestock products and feed, the shifting of demand to less developed countries, integration with global food markets, and continued substitution of livestock food products for cereals in the human diet, Thailand might be expected to show more intensive livestock production close to cities, rapid technological progress for intensive livestock production, and improved efficiencies in grazing and other ruminant management.<sup>166</sup>

This will raise ethical and environmental concerns about such issues as animal welfare, air and water pollution, and genetic engineering in all countries which seek to export livestock products. Nutrient surpluses, from intensive animal wastes, of the order of 1,000 kilogram of nitrogen per hectare per year, globally equivalent to seven percent of the inorganic nitrogen fertiliser produced in the world, can easily contaminate groundwater and wetland ecosystems. Loss of mangrove habitats, high coastal nutrient loads, green house gases, and health risks are already associated with intensification of livestock industries.<sup>167</sup>

Thailand has begun its land and water livestock revolution through the agribusiness activities of CP and others. Further increases in demand will favour expansion of intensive enterprises and offer some opportunities to poorer livestock

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<sup>165</sup> Falvey, L. (1999)

<sup>166</sup> Delgado, C., et al (1999)

<sup>167</sup> Chantalakhana, Charan, et al. (1999)

producers. This will necessitate an improved regulatory environment to maintain export market access. Strong legislative and administrative integrity and an effective education and research sector across all aspects of environmental management for fish and land livestock will be essential.

## **Summary**

Key points pertinent to Thai agriculture from the perspective of livestock and fisheries include:

- Livestock including fish have been integrated to Thai agriculture from its origins, as remains partly evident in subsistence production systems, although self-sufficient production is increasingly linked to the wider economy, thus requiring a means of ensuring that small-holders receive benefits concomitant with risks associated with supplying stock or product to the commercial sector.
- Buffalo numbers are expected to continue to decline, and cattle numbers to rise with meat and milk demand, while chicken, pig, prawn, and other aquaculture production increase in value, and fish catches decline, and goats possibly increase with Asian demand.
- As a leader in intensive chicken and Black Tiger Prawn production as a result of a reliable feed base, multinational agribusiness firms, and government tolerance of environmental damage, Thailand has been a beneficiary of regional market expansion, and is expected to widen its lead while meeting changing international regulatory environments.