NON-VEGETARIAN HISTORIES OF AGRICULTURE

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When animal husbandry is air-brushed from accounts of agriculture, is agricultural history simply incomplete or is it wrong?

Noble grains

From the mid-1960s to 2020-21, the yields of India's high yielding varieties of wheat responded to fertilizer and water and quadrupled, while production increased from 24m tonnes to 110m tonnes. The transformation of rice[2] started later in the 1960s, because its plant architecture made it harder to dwarf to resist heavy fertilizer, monsoons, flooding or drought and cloudy seasons. But from later in the 1960s, rice yields also trebled, and production quadrupled, reaching 122m tonnes in 2020.[3]

There have been many essential conditions for this extraordinary 'Green Revolutionary' achievement which has enabled India to reach food grains self-sufficiency and substantial exports, and which is now criticized for its environmental, social and nutritional impacts.[4] But in focussing on wheat and rice, even mainstream histories of agriculture have missed much out. The NSSO's 2013 definition of agricultural production is generous, including 'growing of field crops (including fodder crops), fruits, grapes, nuts, seeds, seedlings in the nurseries, bulbs, vegetables, flowers, production of plantation crops, production on forest lands, and production of livestock and livestock products, poultry and poultry products, fish, honey, rabbits,

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[1]ENDNOTES

barbara.harriss-white@qeh.ox.ac.uk I am grateful to Prof Sujit Kumar Mishra and the Council for Social Development, Hyderabad, for accepting this lecture, to Prof D.N. Raddy for his chair's comments and to the on-line audience for lively discussion. Tejbir Singh first catalysed it as an essay for *Seminar* (2022-3 vol 761 pp 41-48) and gave permission for me to re-work it and re-publish it. Dr Nitya Ghotge helped with references on Indian pastoralism, Prof Madhura Swaminathan pointed to the Foundation for Agrarian Studies' research on women and cattle and Prof Colin Leys read the first draft closely. Errors are not their fault but I'm very grateful to them all.

[2] Indian output data often confuses rice with paddy – un-milled rice and about 1.5 times heavier.

[3] Government of India 2022.

[4] Patel 2013.

fur-bearing animals and silk-worm cocoons' (NSSO, 2013).[5] You would not know this however from most writing on the products of agriculture. The latter is about noble, and to a lesser extent coarse, foodgrains: which are edible seeds. Even oilseeds, which are grains, and pulses, which are seeds of legumes, rarely feature among these foodgrains.

Indian agriculture is a mixed agri-pastoral project. A century ago, the value of livestock[6] was estimated to exceed that of cash crop production.[7] A century later, it still comprises about a third of agricultural GDP. Alone, livestock is 6% of total GDP and a $213 bn sector. At one bovine for every two Indians, India tops the world in livestock population and in the production of milk. In the 21st century, it is thought that about 70% of the rural population - some 630 m people - keep some livestock and about 20 million rural livelihoods (9% of the population according to some official estimates) depend exclusively on livestock.[8] These large figures do not include the ancillary activities (in leather- and milk-based products for instance) which are rapidly being absorbed into the commodified food industry. The Indian livestock economy is currently growing at four times the rate of crop production.[9] While sheer numbers are concentrated in the 'cow-belt' of Bimaru states, rapid growth which drives aggregate agricultural growth rates is concentrated in AP & Telengana, Maharashtra, UP and West Bengal. Half of India's beef is now exported, and India is the world's second largest producer of leather and shoes. The leather industry is worth $27bn and employs 3m people; in 2015 its exports amounted to $6bn, while exports of meat accounted for $8.3bn in foreign exchange. This activity requires the slaughter of animals, yet the cow is sacred to many Hindus,[10] some of whom are more antipathetic to violence against cows than that against certain categories of people with livelihoods in the animal economy.

Yet despite the importance of cattle as an enduring status symbol of wealth, fertility and bounty, as collateral for loans, as more resilient than crops in India's semi-arid tropics, as insurance against risk and as security in emergencies of health, economy and environment, and as food for the 77%

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[5] NSSO 2013.
[6] The term livestock encompasses cattle, sheep, pigs, goats, buffalo, oxen, llamas, camels, horses, donkeys, and mules. Although we focus on cattle, the least invisible, we are aware that other animals suffer much deeper neglect: Ghotge 2017.
[7] Ware 1936.
[8] GoI 2020.
[9] Data in Swaminathan and Vijayamba 2022.
[10] Jha 2002.

Indian households which eat meat,[11] it seems that animal husbandry is below the radar for all but honourable exceptions among historians, scientists and development policy experts.[12] 'Agricultural social science' tends to be vegetarian or vegan.

Searching for negatives is always risky but a review of volumes on the Green Revolution and on Long-term Village Studies is telling both for what it does not and does reveal about livestock. In Farmer (ed), 1977, *Green Revolution?* focussed on rural northern Tamil Nadu, livestock had a passing mention for their 'widespread centrality' for traction, in particular for land preparation. Land for fodder acted as a constraint on foodgrains acreages, the rotation of animals between bush-fallows and arable land helped maintain animal populations and soil fertility for crops. Yet, the cost of manure and human labour for animal care were not included in the costs of crop production. For Hazell & Ramaswamy (ed), 1991, *Green Revolution Reconsidered,* following up a decade later in the same region, while irrigation had been mechanised, livestock were still essential for land preparation. Yet livestock were aggregated with crops in cost of production data while milk and tanning were treated as part of the non-farm economy, theorised as a multiplier of crop production. The major book edited by Ramachandran et al – with international scope – 2002, *Agrarian Studies* had very little on livestock and the late Yoginder Alakh's, 2013, analysis of the *Future of Agriculture* considered meat, milk and eggs only in passing. Narayanamoorthy et al's edited festschrift, 2019, *Whither Rural India*?, also had little, the exception being Heyer's account of Coimbatore villages in which bullock numbers and work were in decline, while livestock numbers persisted on all sizes of farm. Dairy was especially important for small, landed producers. Lately, Bansal's 2024, *Transformation of Agri-Food Systems* contains an entire chapter on livestock, structured according to the agenda of international regulatory alignment and so focussing on 'yields', health and zoonotic transfer risks. In Gulati et al's 2024 *New Deal for Agriculture for ViksitBharat@2047* there is no serious mention of livestock. Animals might be 'centrally important' but they get scant recognition.

Turning from a set of books on agriculture to a set of books on village economy, Harriss-White and Janakarajan, 2004, *Rural India facing the 21st Century* compared the use and nutrient values of chemical fertiliser with

[11] This essay is about production and to a lesser extent distribution. It says very little about meat consumption where pork is forbidden to Muslims and beef to certain status groups of Hindus and which is a field in its own right – see Devi et al 2014, Filippini et al 2019, and Khara et al 2020.

[12] In 2017, *Seminar*'s volume 695 was entirely devoted to livestock landscapes.

that of manure as compost. But no more. However, in (ed) Harriss-White, *Middle India* (2015), cattle markets, bullock carts, milk, the dairy industry and urban animal and human compost were impossible to avoid in the long-term study of a market town. In Himanshu, Jha and Rodgers', 2016 volume, *The Changing Village in India*, on long-term village studies in India, the decline of livestock economy in Tamil Nadu and in Bihar received short treatment.[13] The provision of meat, milk or even eggs was not recorded in the non-farm economy. Lanjouw and Stern's 2018 collection, *How Lives Change: Palanpur, India and Development Economics*, about a village in UP studied regularly ever since 1957, explained the decline of fodder crops by mechanization, the displacement of draught animals and their replacement by dairy. Later on, we find livestock classified where it belongs as an aspect of 'cultivation', supplying 10% farm income (which must be from milk).[14] But there is little discussion of this significant income source. The Foundation for Agrarian Studies (FAS) is an exception. In their 2023 book on *Economic Change in the Lower Cauvery Delta,* chapter 8 tracks the rise of sheep, goats & poultry throughout all agrarian classes but stresses their importance for small, marginal and even landless households. Livestock rearing is found profitable enough to justify rental markets for animals. Livestock also protects its owners from economic shocks and compensates for negative incomes from crop production. Other FAS reports have revealed the strenuous nature of women's livestock work - occupying between 2 and 8 hours a day. Incomes from livestock and their products have recently risen.[15]

On the whole however, it seems that animal economy is not just a story of blindness on this writer's part but one of almost general neglect in the literature. Some themes - the decline of draught, its replacement by milk production and small ruminants, the value of livestock to hardly landed households – emerge from village studies. But by and large, in this body of work, the analytical status of livestock is unstable and low. For some analysts, livestock is an element of the non-farm economy. In official classifications, livestock is 'allied' to agriculture but recorded separately, thereby enabling it to be overlooked. As long as researchers revisit villages and replicate crop-focused studies, we can expect agriculture to continue to be a vegan, or at best a vegetarian, story.

Could the Green Revolution have happened without animals?

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[13] Himanshu et al 2016. pp. 276, 335, 347, 361 and 363.
[14] Lanjouw and Stern 2018, pp. 175-7 and 251.
[15] Swaminathan and Vijayamba op cit.

During their lives animals produce milk and wool - and chicken and ducks produce eggs – and their afterlives bequeath meat, hides, bones, blood, fibre and other agro-industrial raw materials.[16] For centuries if not millennia and certainly before the Green Revolution in the 1960s, cattle have also been essential to crop production. Bullocks have provided draught power for ploughing, tilling, sowing, weeding, water lifting, threshing, oil extraction, sugarcane crushing, carting and transport. Cows and bullocks also provide 'waste' used for manure, fuel and binding material. By moving seed around, their dung contributes to biodiversity. [17]

Animal husbandry is demanding in terms of human labour everywhere. Finding feed, fodder, water and tending and feeding animals is time consuming. Indeed, another feature that keeps below the radar is that much of this human labour is female: it should rightly be called animal wifery.

In the era of chemicalised agriculture since the 1960s, the high-yielding seeds of the green revolution have been adopted and normalised on (at least) 68% of India's total cultivated land. Meanwhile, despite HYV straw impairing feed, draught power was still reported in 2009 to be used on roughly 60% crop land. And while draught animals have declined from some 80m in 2009 to 31m (and 12 m carts) in 2019, and despite being compromised by fossil fuel energy, it is clear that the *animal-crop relation endures.* Did/does it make possible the GR? Unlike water and chemical inputs is livestock predisposing but inessential?

The case for their being essential to chemical-industrial agriculture is not a general one but an Indian one. It would accept the arguments that cattle compact the soil that they are used to prepare far less than do tractors; that their deployment and dung enhance the organic composition of soil; that their consumption of crop residues in return for manure creates a biochemical synergy quite foreign to machinery; that where machines cannot work small or marginal land-plots, or are unavailable or are excessively costly, livestock enhance the economies of small-scale; that animals do not always or necessarily compete with humans for crop-land and that the association between livestock ownership and income enhancement per unit of land signified a greater capacity for the cash inputs of the GR than did incomes in households without animals. The case is quite strong, even if the evidence for it requires a reinterpretation of the literature and further research.

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[16] Ali 2007.
[17] Vaiyanathan 1978.

Livestock has been a specialist research field for vets and animal genetics but of low priority for social sciences. In what follows, we make a small attempt to rescue a few of the themes of non-vegetarian histories of agriculture, by focusing on mobile and settled cattle and their relation to crops. India's livestock-carrying density is creating competing demands and stresses that are most vividly seen in the least visible sector of all. For this reason, we place the pastoral economy first here.

Pastoral economy and agriculture

Throughout the length and breadth of India, a wide range of animals is reared in ways which always involve their movement, and often involve their migration. At the minimum 13m, at the maximum 80m, people from old and new tribes, numbered at 200 at the minimum and 500 at the maximum, gain livelihoods from pastoralism. Migrant pastoralists herd livestock in nomadic[18] or seasonal trans-humantic movements. More is known about the indigenous knowledge, nature friendly practices and cultural differentiation of these people, about the commodification of their pastoral skills and (thanks to the perverse politics of official downward mobility) their political struggles for identification and recognition[19] than about their animals. Of their livestock's variety – from camels and yaks, buffalo and cattle, through sheep and goats (shoats) to pigs and even ducks[20] – there is no doubt. Of their numbers, much more doubt. References deplore the scantiness or non-existence of information and the 'sad and shocking' silence about pastoral development.[21] One report guesstimates cattle at 165m (79% pastoral), buffalo at 61m (59% pastoral), goats at 103m (80%) and sheep at 60 m (95%).[22] Half of India's milk and 75% of India's meat may come from pastoral production. Yet the pastoral economy is well and truly below the radar.

Pastoral territories have been considered unsuitable for agriculture: arid tracts, hilly and mountain regions. This has not stopped them from being enclosed for crops. The question whether pastoralists now conserve or

[18] Not all nomads are pastoralists. Many pastoralist groups are classified as denotified criminal tribes (Ghotge 2022).

[19] Mayaram 2014; and for a fine history see Bhattacharya 2019.

[20] Sharma et al. 2003.

[21] Sharma et al. 2003; Ghotge 2022.

[22] Chemnitz and Becheva 2014.

desertify such ecosystems depends (rather as it does with societies practising shifting cultivation) on human and animals' demographic pressures on the recovery of resources. The tragedy of the commons, resulting in animal numbers compensating for their poor yields and actively contributing to resource degradation, may be countered by pastoralists' modifying herd sizes to coexist with exhaustible resources and/or competitive species. Mobile animals also disperse in 'biocorridors' the seeds of grasses that are inedible to humans; they check weeds, contribute to soil moisture and fertility and reduce fire risks in dry areas.[23]

Movement and migration involve men minding animals and women minding most other aspects of domestic and social life. Neither men nor women have entirely forsaken horseback for trucks or four-wheel drives. Their established routes matter to crop production because they cross settled agricultural regions. When they halt in these regions, customary relations are activated, and their penned animals provide manure – and energy - in return for stubble and other crop residues for feed. Economic complementarities are also generated between small-holdings and incomes from animals.

But now the networked territoriality of pastoralist livelihoods increasingly butts up against the territorial boundaries involved in settled agriculture. The contemporary tragedy of the commons is one of encroachment and privatisation of forests and grazing pastures. Competition for shrinking pastures and seasonal grazing lands between settled and migrating 'landless' animal husbanders is enhanced by competition for land for settled livestock-crop husbandry. These dramatic changes are disrupting the symbiosis between pastoralism and agriculture. Land converted from millet to irrigated sugarcane for instance becomes useless as fodder; climate change is frying drylands and roasting scrub forest on which animals rely for fodder and forage materials. Migration routes are being physically obstructed by infrastructure such as dams which irrigate and render 'green' for settled farming the deserts of pastoralists. They are also disrupted by non-agricultural rural developments: defence territories and networked transport infrastructure seized through 'eminent domain'; routes and grazing barred by watershed development schemes, by social forestry and new enclosures under Forest Rights Acts, by SEZs, by open mines and by the expansion of private land enclosed from commons or acquired through market transactions. Grazing rights clash not only with private

[23] Ramdas and Ghotge 2006.

non-agricultural rights but also with the privatized environments of expanding cities which block pastoralist migration routes.[24] Migration routes then get diverted, only to clash with other pre-existing nomadic routes. Although herded animals were always sold, markets have penetrated and transformed pastoralism: pastoralists now pay for pens on agricultural land and crop-producers pay for animal droppings; pastoralists pay for grain and food, for mobile phone charging and access to TV, and crop producers pay pastoralists for their farm labour.[25]

In the past they were 'not necessarily poor'[26] and had wealth stored in their mobile banks of animals; even so relatively few pastoralists have the resources to purchase land and sedentarise and many are deprived in terms of the dimensions of human development and access to public goods and services. For All-India, Sharma et al. reported in 2003 that 'there are no official pastoral development policies',[27] that pastoralists lack ministerial representation and face much open official hostility, a situation which appears unchanged.

The Livestock Economy and Crop Agriculture

Over the 20th century, the size and composition of the livestock economy changed dramatically. In undivided India's first census of 1919 cattle and buffaloes numbered 151m;[28] in independent India in 1951 they totalled 198m, and by 2019, 302m.[29] Among the 12 major animal species censused quinquennially since 1919, cattle and buffalo have consistently made up 60% of the numbers.[30] Livestock demographers argue that despite a slowly growing specialization on draught and milk from 1920 onwards, the low-quality, poorly-nourished cattle population exceeded requirements in a dysfunctional way until well into the Green Revolution of the 1970s.[31]

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[24] Chakravarty-Kaul 1990; 1998.

[25] Ghotge 2022.

[26] Ibid.

[27] Sharma et al. 2003; But see Ghotge and Kishore 2016, for an evidence-based 10-point programme for pastoralists.

[28] Government of India 1928, p. 20.

[29] https://www.nddb.coop/information/stats/pop

[30] A standard simplification criticized by Ware 1936.

[31] Harris 1978.

For all the routine culling of male calves after the 1970s however, cattle numbers held up. Without a systematic genetic improvement programme either for milch or draught cattle,[32] India's genetically cosmopolitan herd has gradually been purpose-bred for heat-tolerant, disease-resistant draught and milk, using exotic inseminated germplasm. It was not until the 21st century that the production of frozen straws (semen doses) increased by a factor of six to 65 m/year, with production shifting from the cooperative sector to self-regulated private semen stations.[33] In just 12 years from 2007 onwards the male/female sex ratio for cattle plummeted from 0.72 to 0.32.[34]

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While female milch cows have bred draught-animals, they themselves – together with milch buffaloes – have been providing household income to compensate for that formerly derived from the energy inputs of bullocks which have been displaced by machines. ICRIER (2024) reports a fourfold increase in milk income between 2002-20.

The change from animals for draught to animals for meat and milk has been nothing short of revolutionary. Consistent with predictions that diesel tractors and fertilizers would displace the draught and manuring roles of male livestock, the share of draught animals in total Indian farm power has declined from about 78% in 1960-61 (when a pair of bullocks worked 1200-1800 hours per year) to perhaps as low as 5% by 2020 (and 300-500 hours per year).[35] Yet the total number of cattle has done nothing but rise.

Meanwhile Operation Flood, the equivalent for dairy of the Green Revolution for noble foodgrains, had been launched in 1970. Like the Green Revolution, a state-mediated package of inputs, credit and assured markets, developed through a hierarchised co-operative system, created and improved livelihoods without requiring radical social change – except for the labour requirements of the rapidly feminizing herd. While at Independence milk production was 17m tonnes, by 2007-8, after the 'White Revolution' surge of the 1980s, it reached 104.8m tonnes. Since then, it has doubled, and India

[32] Nimbkar and Kandasamy 2011.

[33] See the references in this article https://asiaconverge.com/2019/09/cattle-semen-breeding-story-india-proud/

[34] Data from the livestock censuses, Pers. Comm. Prof D.N. Reddy.

[35] Gathorne-Hardy 2016; Manomohan et al 2021; Singh et al 2014.

tops the world in milk. The addition of dairying to the provision of traction, organic inputs, beef and leather means that livestock products shot up from being 6% of gross agricultural output in 1970-71 to over 25% in 1992-93 and reached nearly a third by 2008.[36]

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Social Class: While meat is a major contributor to Indian exports, and while commodified chicken and egg production are being industrialized and scaled up in intensive and irrigated factories, cattle in India are not intensively ranched in vast ' improved' herds in the way they are in, say, Brazil. Intensive meat and dairying are not yet widespread.[37]

Instead, about 70% of India's milk and meat markets is thought to be supplied by about 70% of rural households: small and marginal settled farmers and landless households.[38] They rely on rotating seasonal access to local common property resources: grazing lands, forests, margins of water bodies, bunds, fallow land, verge-sides. They glean residues from crop production: leaves, stalks, stubble and roots (plus post-harvest husk, haulms, cobs, shells, bran and pith). Whereas most cultivable land – on average 94% – is down to crops[39], only 12% of the land of marginal farmers is cropped. The rest has been used for livestock – generating up to 70-80% of their annual income, although this is rarely recorded.[40] Where surveyed, these small enterprises produce milk and manure more efficiently than larger ones. Among the large group of disadvantaged livestock producers, landless households face increasing barriers to feed and forage.

Social identity: The livestock economy is disproportionately a sector for Tribal people, Dalits and Muslims. Yet Dalits have regularly been found to face significant barriers to livestock ownership in the form of barred access to commons, lack of land, investment resources, access to co-ops, markets, extension and veterinary services, and price discrimination for both fodder and milk.[41] Muslim livelihoods are grounded in agriculture and its

[36] https://www.nddb.coop/information/stats/GDPcontrib
[37] Ghotge 2017.
[38] Ramdas and Ghotge 2006.
[39] This may include fodder crops.
[40] Singh 2012; Singh et al 2022.
[41] Sarkar 2020.

multipliers – renting out draught animals, cattle transport and trade, slaughter, tanning and leather work and processing of other parts of cattle carcasses..

Gender: Inside the 'black box' of the family labour-force, animal husbandry is work for women and children who typically rear one or two cows or buffaloes, with cultivated feed, crop residues and by-products, food waste and fodder foraged from common land. Women dominate the labour-intensive tasks of harvesting, transporting and chaffing of fodder, feeding, milking, cleaning of cattle sheds, and the preparation and sale of milk products. Often multitasking and interleaving livestock work with other household-reproductive tasks, the scale of their effort is once more 'under the radar'.[42] In one case study, a woman's unreported livestock activity added up to 3.5 hours a day, in another up to 8.[43] Whereas a third of dairy co-op members are women, men are found to control investments (and insemination).[44] But when menfolk migrate for work, women left behind may have no options but to reduce their livestock work.

Feed: What does India's huge livestock population eat? Yet another below-the-radar feature of the livestock economy is animal nutrition and its relationship to crop production. This specialized sub-field of veterinary science is replete with papers discovering and deploring seasonal deficits in the complex of key nutrients needed for cattle health. India's cattle population is considered undernourished. Like humans they suffer 'hidden hunger' and so are malnourished too.[45]

Fodder crops, cultivated or harvested for feeding animals, take the form of forage (cut green and fed fresh), silage (preserved under anaerobic conditions) and hay (dehydrated/dried forage crops). Sorghum and clover account for half of India's fodder along with maize, oats and gram. Paddy and wheat straw provide roughage. Apart from a few examples of finely crafted haystack architecture, India seems to have little history of barns or

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[42] Jeffery et al 1989.

[43] Swaminathan and Vijayamba 2022; Patnaik, 1983, reported that in Haryana, studied in the 1980s, '84 per cent of the women in the labourer families returned themselves as workers, though only 51 per cent were engaged in wage-paid work' the rest occupied unpaid with cattle.

[44]; Moore 1978; George 1996; Swaminathan and Vijayamba ibid.

[45] Not helped by state neglect of veterinary science and the proliferation of veterinary quackery (Ramdas and Ghotge 2006).

stores for harvested fodder. As for pastoral livestock systems, tree crop fodder, particularly important for the cattle of smallholders or landless households, is subject not only to local tragedies of the commons in its classic formulation but also to the diminishing of the commons through encroachment, privatization and commodification for crops.[46] For livestock the tragedy of the commons is one of diminishing sources of feed. Fodder seed has remained of poor quality, some of it not even domesticated. Forage grasses and legumes are perennial, and self-seed. Pastures are declining both in area, due to competition from crops, and in quality, due to overgrazing. Even by the early 21st century, the deficit of dry crops stood at 20%; that of green fodder crops at 40-60%; crop residue deficits were 11 %, forage crops 80% and commodified feed 45%. [47]

Cattle fodder is increasingly commodified in the shape of bran and the husk of food grains, broken grains, oilcake, and de-oiled bran residue.[48] In the 21st century feed and fodder account for over two thirds of the commodified costs of animal production. Outside the trade, practically nothing is known about the impact of this aspect of agricultural commodification on male-female work burdens, decision-making or control over household budgets. We do know that prices of green fodder tripled between 2011 and 2016, necessitating their partial substitution by compounded commercial feed and producing an acute cost-price squeeze both for milk and for cattle.[49] By 2022, because of the rapidly growing commercial feed industry, the crisis had shifted to feed concentrates, where the shortfall was estimated at 44%. Singh et al (2022) find that in the competition between humans and animals over land and crops for food, India's animals have half the fodder they need. Their overview of India's fodder economy concludes strongly that its crisis results from a vicious circle of scant and unsystematic state budgetary allocations for research and development, lack of expertise, corruption and fraud, lack of data, lack of recognition and lack of interest, While milk production has been measured as continually increasing, there appears to be no fodder lobby, no demands or claims on local or central states, no outcry from milk co-ops.[50] The statistics on cattle numbers and what they eat don't add up.

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[46] Jodha 1990.

[47] Jitendra 2017; Venkateshwarlu and Prasad 2012.

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[48] George 1996.

[49] Jitendra 2017.

[50] See Jitendra ibid for a case study of subsidised water-fodder and cattle camp projects in Marathwada, Telengana and Karnataka.

Environment relations: We have already seen that crop and animal production are related in an ecologically complementary way: the energy and manure of animals are a resource for crops, and straw and other residual waste from crop production is feed for animals.[51] When incomes from small-scale crop production that experts consider 'unviable' are supplemented by the returns from livestock effort and products, they are economically complementary too.

In contrast, just as the commercialization and chemicalization of inputs to plants have rarely been free from inefficient take-up, resulting in the pollution of water and the denitrification and mineralization of soil, so the commercialization of livestock feed and the burning of crop residues extract soil nutrients without compensation and exacerbate physical and chemical imbalances in the earth's outer crust – imbalances now termed the metabolic rift.[52] Tractorization and the mechanization of lift irrigation are understood to widen this rift further. Once more under the radar – or perhaps so invisibly far above the radar in the 'dustbin in the sky' that detection is a matter for environmental science – the imbalance is gaseous as well as liquid and solid.

Using life cycle assessment which computes one of the major environmental externalities, gaseous emissions, throughout the life of a process and/or technology, research in puddled paddy fields has generated estimates of the green-house gas trade-offs in the replacement of bullocks by tractors and the replacement of their manure by fertilizer. While in ploughing and levelling there may be no significant difference in GHG emissions of bullocks and tractors either per hour or per hectare, bullocks are deceptive because they continue to emit GHG when not working – in a ratio of 10 idle hours to one working hour.[53]

When it comes to fertilizer, the GHG emissions from animal manure are a third higher per unit of nitrogen than those from chemical urea. They emanate from enteric fermentation and from the way manure generates feedstuff for other methane-generating species in flooded fields. Manure is un-costed but three times more labour-intensive to apply than chemical

[51] Gathorne-Hardy 2016; Raghuram 2022.

[52] For a valuable demonstration of crop-animal interactions and metabolic rift (in China) see Xu and Je 2022.

[53] Gathorne-Hardy 2016; see Sinha and Ahmad 2017 for working tractor-years of 850-1000 hours. See Pandit et al. 2019 for data for a bullock's working year of 480-500 hours.

urea; but manure has huge benefits for soil health and biodiversity which urea lacks.

These cases of animals and industrialised rice production technology teach us that even simplified environmental impacts are not straightforward.

The relative invisibility of livestock in research and data collection on Indian agriculture is not matched by invisibility in ecological debates. Alarming planetary statistics for livestock emissions (14-20% of *all* GHGs according to some sources in the IPCC and FAO[54]) underpin advocacy for 'dietary behaviour change': for vegan or vegetarian diets grounded in ecological principles rather than the food rules of upper castes.[55] Uncontested Nitrogen science underpins the case for legume-based diversification capitalizing on nitrogen-fixing microbes living symbiotically in the root nodules of legumes.[56] Suggestions for reductions in animal methane production range from high-tech feed to low tech increases in the workloads of bullocks.[57] It is not uncommon however to find agro-ecology (under one of its many labels) being discussed in the literature without mention of animals at all.[58]

Such 'vegan' approaches to Indian agriculture avoid considering essential agri-pastoral chemistry and biology.

In this vegan context, the practices of Palekar's Zero Budget Natural Farming may be unusual in incorporating cattle into 'ecological' crop production. Urine is needed for the microbial coating of seeds, urine and manure for the improvement of soil microbes, manure is an optional need for mulch and it is only the reduction in tillage intensities which aerate the humus and top soil which does not explicitly require animal inputs. With 700,000 adopters in 2023 [59], approval from the Governments of Karnataka and Andra Pradesh, from the central Indian government and from a number of broadly supportive academic evaluations,[60] the question for this essay is

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[54] See Herrero et al. 2013; Caro et al. 2014.

[55] EAT Lancet Commission 2019.
[56] Meena and Kumar 2022.
[57] Gathorne-Hardy op cit.
[58] See Jayaraman 2021; see Paliath 2022, for a conversation with sustainable farming expert P. S. Vijayshankar.
[59] And an original target of 6m by 2024.
[60] Reddy 2022; Dorin 2022; Duddigan et al 2023.

the relation between agro-ecological practices in the shape of collectively managed natural farming (or ZBNF) and animal economy.[61]

For it is on such grounds that official organisations like NABARD and the National Academy of Agricultural Science, heavily invested in intensive technologies, criticise the capacity of the crop-animal ratios, that are either assumed by Palekhar or in existence on the land, to enhance or maintain yields. Soil scientists Smith et al (2020) find that while managing nitrogen is essential for yields and for the mobilisation of other essential fertilising elements, the nitrogen fixed by legumes or soil microbes without further enhancement is a limiting constraint on yield. They find that manure is also essential for soil nitrogen. In the absence of chemical fertiliser, manure is a limiting constraint in natural farming due to traction technologies which now result in inadequate cattle densities.[62] To this argument can be added that manure supplies are constrained by alternative uses of dung (down from 43% for manure in 1970s to 13% by the 1990s). In some canonical formulations of ZBNF, animal inputs are not mentioned. Palekar himself in interview has expressed ambivalence about the role of the cow[63] but his question is whether livestock are needed on the land at all, since animal inputs including pesticides derived from the desi-cow could be produced in specialised units – not at zero budget however.

Animal Waste and Crop Waste: The recovery, recycling and reuse of chemical and organic nutrients in livestock and crop wastes are infant industries - part of the family of technologies invoked for the circular economy. These wastes are often described as extensive. Crop residues are essential to mulch and to the preservation of soil structure, moisture and organic content, but they also fuel domestic and industrial feedstocks (for paddy parboiling, brick and lime kilns for instance). Crop 'wastes' are used

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[61] A growing literature discusses the need for additions to the four practices – for instance polycropping together with institutional preconditions such as state support (led by Sri Vijaykumar, IAS), subsidies (some donated by Azim Premji), institutional innovation (Ryuthu Sadhikara Samstha (a new state corporation), collective knowledge-sharing and action involving all villagesociety including landless labour households (see Dorin 2022). This literature also analyses problems of technical knowledge, complexity, context specificity and neglected areas of agricultural research (e.g. worms, bacteria etc. the roles of family labour, yield resilience, markets and price instability and *lack of desi-cows (*see Reddy 2022).

[62] Smith et al. 2020.

[63] 'Palekar claims that the urine and dung from one cow are enough for farming 30 acres of land and so cow ownership by each individual farmer is not necessary. In places where local cows are not available other alternatives of other animals like buffalos or even human urine can be used', p 331 in Choudhary et a.l 2023.

for animal bedding and litter, packaging, compost, oil extraction, thatch, paper, construction and more. Each crop has its own pattern of residue and of residue uses. Incompletely commodified and changing in combinations and composition,[64] there is intense competition for residues for all these applications.

For some time, agricultural residues have been being scoped for alternative uses to animal feed and soil health; but their potential as raw material for textile composites, composite wood substitutes, bio-gas and fuel-briquettes is compromised by variations in existing uses and existing markets and by ignorance. To take one example, the 'gross technical potential' of bioenergy in India is somewhere between 160 and 850 million tonnes,[65] mostly from foodgrains, sugar cane and pulses. In fact, perhaps as little as 15-25% of the 'potential' raw material for biofuel is available, and relative prices are thought to be volatile (and a matter for local knowledge rather than that of the state).[66]

The availability of residues varies with crop rotations and seasons. Some of it needs unplanned pre-processing which adds to costs. Much the same argument applies to animal wastes and biofuel. In a paradox, cost-benefit analyses of biofuel technology from agricultural residues and from animal wastes mostly ignore the existing economy, especially its human and animal livelihoods. If the raw materials are already being used, then new composting and biofuel technology will operate at lower capacity, and economic returns, than assumed in the cost-benefit calculations. If the new technology operates at high capacity, then the livestock economy will be damaged. By 2010 just 0.8% of the total installed electric capacity in India came from biofuel, mostly using off-farm woody residues, with capacity utilization leaving much to be desired and 'exhaustion effects' creeping in, in some instances.[67]

Milk and Markets: Of all the varied food-based products generated by the livestock economy, milk is thought to provide about two thirds of its total value.[68] In the contemporary era, only about a fifth of marketed milk is

[64] Singh et al. 2021a.
[65] Reviewed in Milhau and Fallot 2013.

[66] Ibid.
[67] Ibid.
[68] Ali 2007.

supplied to the co-op sector. The most successful co-op, Amul in Kaira, Gujarat, was established in 1946 as a three-tiered organizational and technological system anchored in village supplies and small consignments. The Amul cooperative still follows the model of the enlightened engineer, V. Kurian: federated, controlled by producers, with rapid cash purchases priced according to fat content. It now exports milk products to the USA, Europe and South and Southeast Asia.[69] But by far the most milk – 70% - is sold to unregistered dealers at flat rates irrespective of quality[70] and at a lower share of the final rupee than is obtained in co-ops. They supply an unregulated system lacking in infrastructure but crammed with intermediaries who rush commonly adulterated milk to urban consumers.

Large numbers of cows end up in urban back-street micro-dairies: free-grazing the urban commons, fed on urban food-waste and vegetable market residues, and supplying fresh milk to the suburbs. Meanwhile live animals are sold to traders or via commission agents at the farm-gate or at periodic marketplaces at prices reported both as 'secret' and as responding to 'observable characteristics'.[71] Cattle markets, vastly oversimplified as 'value chains', are also described as 'decentralised, 'fragmented' and 'unorganised'. Such adjectives ignore the historical fact that there have long been cattle trails linking a network of periodic markets the length of the country. These market places are often rented through auction and privately managed. Cattle are then slaughtered mainly by Dalits for consumption mainly by non-upper caste Hindus and for skins for the leather industry (often managed by Muslims and worked by Muslims and Dalits).[72]

Post-production policy: Cow slaughter and meat-eating are both controversial practices that are necessary to the agri-pastoral system, but which have both been periodically banned – cow slaughter was banned even by the meat-eating British, who in 1944 became worried about cattle numbers. But the newly independent Indian government, concerned even then with leather exports, pressured states against banning slaughter – without success in just four cases. Now, India is dotted with illegal slaughterhouses where hygiene is not a priority that might be enforced by independent inspections; cattle rustling is reported as common, as is smuggling cattle across neighbouring frontiers.

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[69] Rajendra and Mohanty 2004.
[70] Kandhpal and his team (2012) found 80% samples of milk adulterated with water.
[71] Kumar et al 2019.
[72] See references in Kennedy 2017.

Since 2005 when the Supreme Court upheld the constitutional validity of cow slaughter bans, the livestock economy, with its large numbers of livelihoods criss-crossing the country, has been much disrupted by bans enacted with varying scope (and enforced to varying degrees by cow vigilante protection groups) across 20 of India's 28 states.[73] In 2017, slaughterhouses and the cattle trade were also banned by the central government but, after widespread protests, this had to be dropped. Between 2014 and 2017 however at least 200,000 live cattle worth an estimated $36m had been seized from Muslims alone by gau rakshaks (cow vigilantes), cooped up in shelters and then sold to Hindus for agricultural work. Starving feral cows are starting to be reported invading and rampaging through fields.[74] In a quantitative step-change intensified by slaughter bans, according to reputable press reports, millions of cows are reported to be driven from north and north-west India (by intermediaries licenced for intra-state trade who liaise with legally licenced inter-state transporters who liaise in turn with smugglers) across the open marshy borders for slaughter in Bangladesh. Muslim festivals spike this trade. This locally labour-intensive smuggling route, impossible without state and social complicity on both sides of the frontier, is used to launder not only money but also animals.[75]

A new scale of organised meat processing reinforcing the export industry is also being state supported at the expense of the multitude of self-employed and small business livelihoods still in the mainly unregistered informal economy.[76] The rapidly differentiating outcomes of the 'conjugated oppression' meted out to livestock workers[77] include estimates of 1-3m livelihoods destroyed in the livestock economy before 2017 alone – more in multiplier industries such as leather and shoes, and countless more in the domestic work of women, stitching gloves and leather goods.[78] The wages of those still in work have dropped. Considerable amounts of foreign exchange have been forfeited – exports declined by 40-50% from 2015 to 2020 – while international demand dropped.

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[73] Editorial, *Times of India*, 2005.

[74] Gowen 2018.
[75] Goswami 2019; Javed and Mahato 2023.
[76] Hussain and Haider 2024.
[77] For conjugated oppression and pastoralism, see the case of camels in Narayanan 2021.
[78] On top of the devastation after demonetisation, GST (Goods and Services Tax), labour law reform and poor to non-relief during covid.

Incomplete or wrong? Animals and the Agrarian Crisis[79]

While since 2020, farm protests have made the crises of crop production politically visible, India's livestock economy, with perhaps as little as half the feed it needs for adequate nutrition, is also in crisis. For as well as one of health there is another of economics and profits. Between 2011 and 2016, green fodder prices tripled. Substituting commodified feed for fresh fodder hikes costs - which have led to the same kind of cost-price squeezes for milk and cattle as have been widely reported for noble and coarse crops.[80]

Livestock are imbricated in the human-animal competitions not just for land and water but for their products and for their residues. Stubble and straw burning in order to fast-track the recycling of nutrients into soils that are bearing fast turnarounds between seasons contributes not only to public health hazards but to the ongoing nutrition crisis for livestock.

The on-going, but far from complete, substitution of mechanical energy for animal and human energy has seriously reduced the bio-physical synergy between crop waste and animal waste and exacerbated physical chemical and biological imbalances in soils. Pollution from chemical-mechanical agriculture and waste has also resulted in animal diseases as well as in human diseases - to which labour used for crops and livestock is not immune.

The contribution of the state to the livestock crisis: While the milk sector is widely agreed to constitute a development triumph, other state initiatives

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[79] 1. Habitat depletion and land-water conflicts i) between humans and wild animals; between wild and domesticated animal and between animas and crop. 2. While cattle constitute two thirds of all bovines, other non-veg histories are likely to be specialised in relation to crops: Buffalo, sheep and goats, fish (salt and freshwater), rabbits, ducks/poultry/pigeons, rats, reptiles, insects (from pests to bees), worms & nematodes, even ?fungi? and microbes. 3. 'Bushmeat' (eg deer, boar, reptiles, fish, birds) will trace a story of habitat degradation, over-poaching (with little vigilance), commodification,- links with deforestation for expansion of cultivated land, all of which threatens tribal societies. 4. Changes in the absolute and relative prices and the consumption of non-crop dietary elements in which, despite religio-cultural pressure towards vegetarian diets, fish, poultry and mutton are on an expansion path in the 2020s.

[80] Singh et al 2021b.

are considered 'fragmented'. A reading of a sample of them suggests two broad problems with policy. First its technocratic nature betrays lack of knowledge of real-world conditions. Ambitious policy-shopping lists include an 'animal aadhar', international health standards, improved regulation of antibiotics, purification of run-off water, demand-side school food items, 'organised marketing', high tech animal feed, an 'increase gazing lands', improved 'entrepreneurship' , and improved breeding of small animals. The implications for infrastructure, technology, expertise and budgets of such a list are missing. Second and controversially, the policy agenda remains prone to vegetarianism._Livestock get low recognition in policy (for instance there have never been MSPs for animals). They fetch an indifference which results in very low budgets for R&D, underdeveloped expertise, a quality of data that is poor despite 5-yearly censuses and delays both to claims on the state and to action by it that are exacerbated by corruption. If at all, meat is a politicised policy sector for diets, consumption and human nutrition.[81] Animal-crop relations of production and distribution, the focuses of this essay, are neglected.

In sum: animals and crops

'Livestock' is conventionally mis-classified in official statistics, where experts anyway reckon that the sector and its employment multipliers are underestimated. It is analysed, if at all, as a sector in the rural non-farm economy or as 'allied' but separate.[82] In fact, animal husbandry is integrated with agriculture, a specially vital supplement to land-scarce smallholdings and to their farm income, a complement to farm inputs, a significant and enduringly unrecognized part of the productive burden of rural women, and a semi-monetized subsidy to crop production without which the latter would be compromised. And while milk production is one of India's triumphs, livestock face widespread official indifference or outright hostility. The crises

[81] Samos 2024.
[82] Coppard 2001.

of livestock in general and cattle in particular are yet two more of the many crises of agriculture.[83]

[83] Harriss-White 2021.

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