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Livestock Farming in Indian Agrarian Change: Does it Benefit the Poor?

L'élevage dans la transformation agraire en Inde profite-t-il aux pauvres ?

¿En la transformación agraria en la India, la ganadería favorece a los pobres?

Claire Aubron, Sébastien Bainville and Olivier Philippon



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Livestock Farming in Indian Agrarian Change: Does it Benefit the Poor?

Claire Aubron
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ABSTRACT

Based on 13 field studies, this paper provides an integrated interpretation of India's Green and White Revolutions. Livestock farming, which used to play a key role for cultivation, has been marginalized by irrigation. Large landowners with access to water have tended to abandon livestock and focus on irrigated crops for which they hire labourers. Smallholders and landless labourers are, for their part, massively involved in livestock farming. However, dairy farming generates income that is all the lower as access to resources is limited. Hence, the White Revolution has not proved an effective way out of poverty, but combined with the Green Revolution, it has allowed agricultural productivity to increase, thus limiting rural exodus, without deeply transforming land distribution.

KEYWORDS

livestock farming, Indian agricultura, White Revolution, Green Revolution, comparative agriculture, India

Introduction

India's Green Revolution was a success to the extent that it allowed this vast country to achieve and even surpass national cereal self-sufficiency in few short years, despite high demographic growth. Based on "technical packages" developed by agronomic research stations, it was however criticized for its exclusive nature (Dhanagare, 1988; Harriss-White & Harriss, 2004). The conditions required to implement the new cropping systems (particularly access to irrigation), in fact meant the innovations, were limited to the regions that had the greatest access to water and to the richest strata of Indian farmers.

Less well known, the White Revolution was provoked by the dairy farmers' struggle against the monopoly dairies enjoyed during the colonial period. In 1946, the first cooperative was created in Gujarat, and a whole decentralised collection network was quickly established. In 1964, the Indian government decided to promote this model throughout the country and entrusted the implementation of the "Operation flood" to the National Dairy Development Board (NDDB) (Cunningham *et al.*, 2009; Dorin & Landy, 2009; Scholten, 2010). The White Revolution was just as successful as the Green Revolution in terms of production growth, but as it was based on the participation of poor or landless farmers it has often been praised for its inclusiveness (Atkins, 1988; Khan *et al.*, 2010), so much so that it is quoted by the World Bank as a model for Africa (World Bank, 2012).

Situating these events in their geographical context and in a historical perspective allows us to suggest another interpretation. Rather than two parallel revolutions, the Indian countryside experienced a single and same agricultural revolution. The two processes are closely linked at the technical and socio-economic levels, and their inclusiveness or exclusiveness cannot be assessed separately.

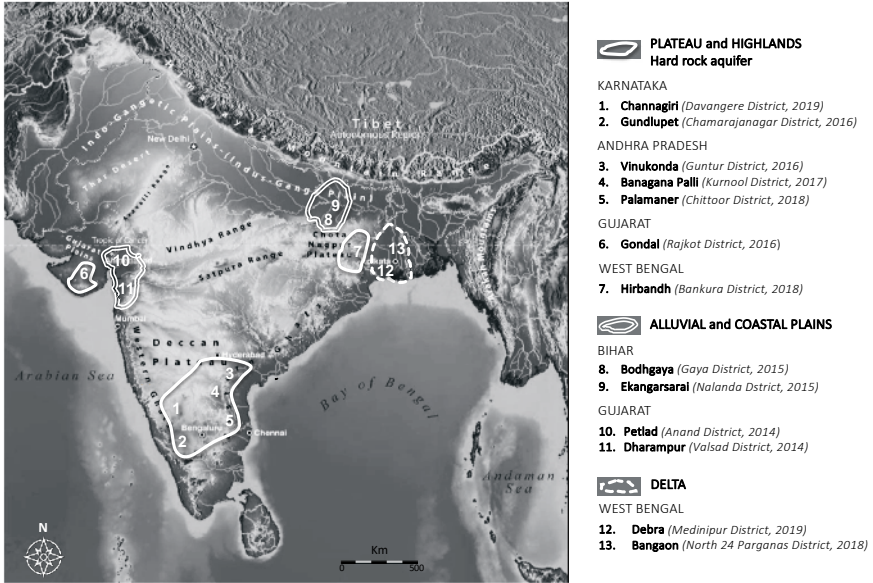
This argumentation is based on the study of agrarian dynamics in thirteen small regions in India, and the role livestock farming plays within them. These thirteen study areas were gradually selected in the framework of a research project (IndiaMilk project, 2014-2019) so as to cover a range of contrasting situations in terms of biophysical environment, land tenure, historical development of irrigated agriculture and dairy farming. Located in

five states, these small regions all saw irrigation develop from the 1960-1970s onwards, but it took different forms, partly due to contrasting biophysical conditions. On plateaus, in alluvial plains or in deltas water management differs greatly (Fig. 1). In addition, the regions were all involved in the development of dairy production and daily milk collection, though more or less precociously (between 1960 and the 2000s).

To study these contrasting combinations of the Green and White Revolutions, we used a “comparative agriculture” approach that allows for a combination of disciplines and scales of analysis (Dufumier, 2007; Cochet, 2012; Cochet, 2015a). In each of the thirteen study areas, we first characterised the biophysical environment on the basis of observations and reconstructed the agrarian history of the last decades through interviews with older people (20 to 50 people in each study area). This material – a situated understanding of differentiated trajectories of farms over the last decades – helped us to develop a preliminary typology of farms in each study area (Cochet & Devienne, 2006). This served as a basis to define a sample that then allowed us to analyse the technical, social and economic functioning of each of these production systems¹ in greater detail, drawing from twenty to eighty interviews with farmers in each study area. Finally, we modelled the diversity of production systems, by creating archetypes that were each representative of groups of farms (Aubron *et al.*, 2016; Lacoste *et al.*, 2018). The figures presented in this article are taken from this modelling process, focusing for some of them on three study areas representative of the three types of cultivated ecosystem, respectively Gundlupet (Karnataka, semi-arid plateau with hard rock aquifer), Petlad (Gujarat, semi-arid alluvial plain) and Debra (West Bengal, humid delta).

1. The production system concept applies to “a group of farms with the same resources (same amount of surface area, same level of mechanization, same size of labour force) in similar socio-economic contexts, with a similar crop mix – in sum, a group of farms that can be represented by the same model” (Cochet, 2012).

Figure 1. Location of the thirteen study areas



Legend: On the basis of climatic and geomorphological characteristics, the thirteen study areas can be classified as three main types of cultivated ecosystems: (i) semi-arid plateau zones (1,2,3,4,5,6,7); (ii) sub-humid (8,9) and semi-arid (10,11) alluvial plains and (iii) the humid delta region (12,13).

Source: Elaboration by the authors, 2023.

1. The Former Land Concentration and Mixed Crop-Livestock Farming Systems

Despite great diversity, just after Independence the thirteen situations studied showed strong similarities in terms of social organisation and technical functioning.

1.1. High Social Differentiation

Social organisation in the 1950s was marked by high differentiation based on access to land. Depending on the small region studied, the areas of large properties varied between one to several tens of hectares, and there were different land and taxation regimes – see Bandyopadhyay (1993) and Ludden (1999) for further details on land regimes. The number of strata and the castes that composed local societies in 1950 were not the same across the study areas. But everywhere, land was concentrated in the hands of few

landowners from diverse communities (e.g. Patel in Gujarat, Lingayat in Karnataka, Reddy and Kamma in Andhra Pradesh, Rajput in Bihar) and was actually worked by tenants, smallholders and landless labourers of lower social status. In the thirteen study areas, landless labourers were permanent labourers in 1950, and some were in a situation of bonded labour² as described by Prakash (1990) in Bihar, and Breman (2007) in Gujarat. At the scale of India, these agricultural labourers represented 38% of the working agricultural population of the time (Pouchepadass, 2006). Among the households who had access to land, different situations prevailed, composing a rural structure that “was like an onion with many layers” (Bandyopadhyay, 1993). Occupancy tenants thus had hereditary customary rights, while tenants-at-will lived under the constant threat of expulsion by the owner, as did many sub-leasing sharecroppers. Whether it was the local king, a *zamindar*³ or the State that received the money, the high land tax, between 25 and 50% at the time in the country (Singaravelou, 1986), limited investment by those who had access to land. In addition to this skewed land ownership there were great inequalities in the access to credit and market. Capital was accumulated in the hands of the minority of large landowners and rural merchant-moneylenders (Markovits, 2004).

In addition to these social categories defined by access to cultivated land and participation in cultivation work, in ten of the study areas located on the plateaus and in the alluvial plains there were pastoral communities (e.g. Rabhari and Bharvar in Gujarat, Yadavas and Sugalis in Andhra Pradesh) or tribal populations that owned herds of ruminants. The former, who had no cultivated land but had access rights to grazing areas and were historically very mobile, are illustrative of the pastoralists in India who have been the object of a variety of studies (Agrawal, 1993; Murty, 1993; Robbins, 1998; Tambs-Lyche, 2008; Duncan, 2013; Axelby, 2016). For their part, the tribal populations in the small regions studied lived in wooded areas, or on their fringes, and combined livestock farming with gathering activities and the cultivation of small fields using slash and burn techniques, as described in other regions of India (Saldanha, 1990).

-
2. Bonded labour is defined as “forced labour for a fixed time without being paid, often as a way of paying a debt”.
 3. Intermediary tax collector from the Mughal period and taken up by the British.

1.2. The Key Role of Livestock for Agriculture

At the technical level, the preponderance of rainfed crops was a first common feature in the agriculture of the thirteen study areas after independence. This was coherent with the limited means of irrigation available to farmers at the time, both from a financial perspective, given the high taxation they were subjected to, and from a technical perspective. Very diverse irrigation or water management systems (wells, tanks, ponds, ahar-pynes, dams, etc.) that were often several centuries old (Pant & Verma, 2010), existed in eleven of the study areas, but they only enabled irrigation in a very low proportion of the cultivated land and for a part of the year (Fig. 2). For the most part, crops were hence dependent on the monsoon. Rotation was dominated by cereals sometimes associated with pulses (or followed by them when the pedoclimatic conditions permitted a second crop cycle).

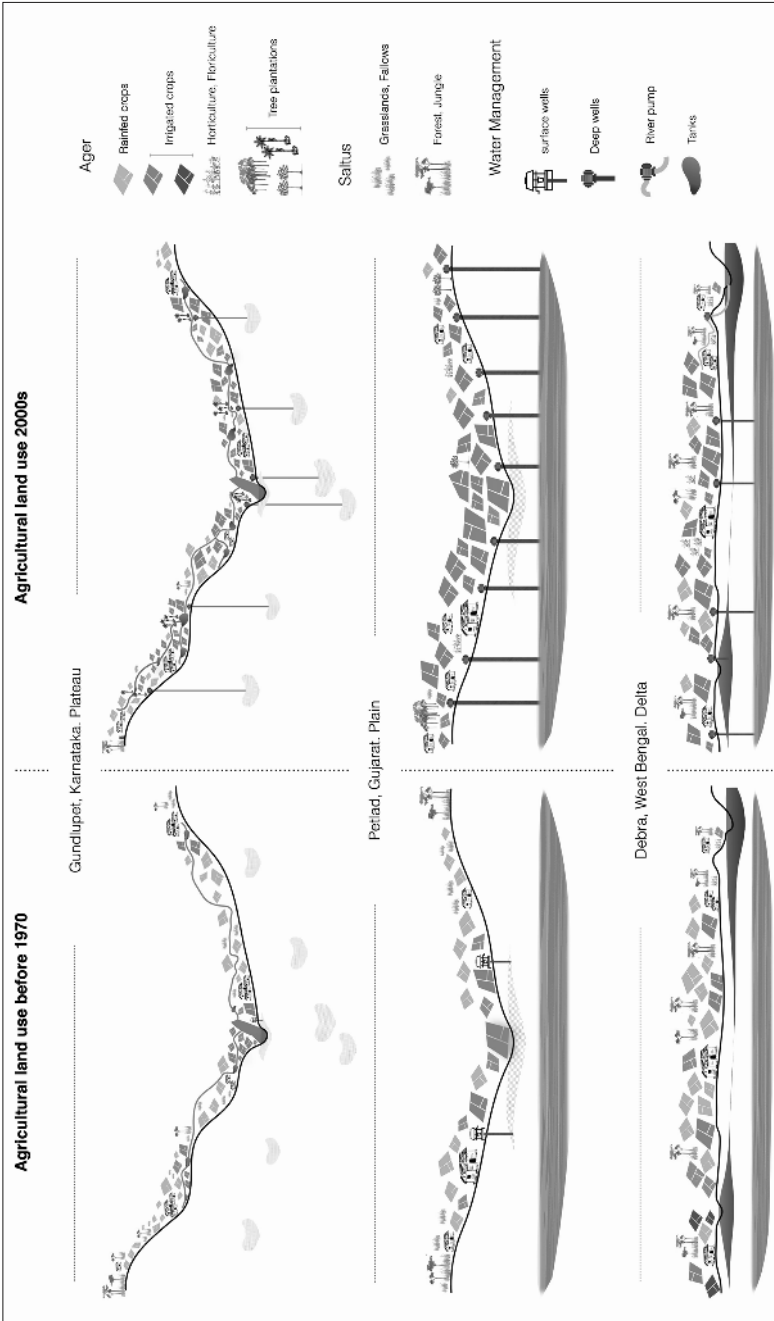
In 1950, the key role livestock played in this agriculture was another common feature of the situations studied. This role was visible in the landscape that included much larger grazing areas than those existing today (Fig. 2): in the eleven study areas located on plateaus and in alluvial plains, uncultivated zones were crossed by the pastoralists' and farmers' herds. Harvested fields that served as grazing land completed the livestock feed. In the two study areas in the delta, where almost the whole area was cultivated, grazing on fields outside crop seasons represented the main source of fodder for the herds. Residues of harvested crops (cereal straw, groundnut hay) or from post-harvest transformation processes (cereal brans, cotton or mustard cakes) were distributed in addition to grazing, by farmers who had access to these resources.

In the thirteen study areas, livestock played three key roles, two of which were indispensable to crop cultivation in 1950. Mechanical energy provision was a first role: bovines carried out certain crop operations making use of diverse implements (mainly for ploughing the land and weeding), transported matter in carts and lifted water in regions equipped with Persian wheel wells. Having access to draught power to work the land was all the more crucial in regions where the soil was clayey and the monsoon defined a limited time frame for cultivation. In black soil or vertisol in the semi-arid areas of Gujarat and South India, three or four pairs of draught animals were sometimes used

simultaneously on a field. Different breeds of draught cattle were employed, as a result of a progressive historical selection of animals appropriate for these ecosystems and for the work they were expected to perform (Raina & Dey, 2016) (some examples for cattle are: Kankrej, Ongole and Hallikar, see Singh – 2000 – for a national view of this diversity). Ownership of draught animals was proportional to access to land, and landowners generally owned several pairs. In Petlad and Gondal in Gujarat, as well as in Gundlupet in Karnataka, pastoralists were nonetheless involved in breeding draught animals that they then sold to farmers, as mentioned by several authors (George, 1985, quoting Kulkarni's work, 1953; Sharma *et al.*, 2003).

Ruminant breeding also played a key role in the fertility management of cultivated land. This role of livestock was widely analysed by French geographers regarding Africa in the 1960s: thanks to their mobility between common pastoral land grazed in the daytime (*saltus*) and cultivated fields (*ager*), the animals ensured a nutrient transfer essential to crop yields (Sautter, 1962). Such practices were more recently described in Soudano-Sahelian Africa (Bainville & Dufumier, 2007; Bainville, 2016) and in certain regions in India (Wade, 1985; Krishna & Morrison, 2009). In the alluvial plain and plateau areas analysed here, the manure was spread either directly by leaving the animals on fields in the night, outside cultivation periods, or indirectly after it had been stored on manure heaps close to the sites where the animals were gathered for the night. In the two delta study areas, these fertilisation practices were reduced due to the limited area of the *saltus* (Fig. 2) but the land benefitted from alluvium deposited in the former riverbed of the Ganges (Bergmann, 1959). Furthermore, in all the study areas, animal manure represented a welcome organic amendment. The incorporation of this organic matter softened the clayey soil that was very compact at the end of the dry season, thus facilitating its preparation for sowing. This also increased the soil's water retention capacity, which was particularly useful in semi-arid areas. As described by Wade (1985) and Tambs-Lyche (2008), the pastoralists entered into agreements with the farmers regarding access to grazing areas and to manure, and thus made a major contribution to fertility management. Their large herds – a few dozen and up to about a hundred sheep and goats, sometimes associated with bovines or buffalos – contributed to intensifying fertility transfer and the recycling of organic matter.

Figure 2. Transformation of agricultural land use in three study areas



Source: Elaboration by the Authors, 2023.

Food provision represented the third role livestock played, either through milk production, which was mainly consumed by the families themselves, or meat, generally consumed by the lowest castes and Muslims, in line with the holiness of the cow in Hinduism. Depending on the regions, milk was produced by cows, female buffalos or both, with a diversity of breeds here too, often different to those used for draught. When the quantity of milk produced exceeded the family's requirements, it was sometimes gifted (Duncan, 2013) and more rarely sold. In Bihar, another animal product, dried dung cakes, completed the picture. In these two study areas that no longer had ligneous resources, they were used as a fuel source for cooking, as in many other places in North India (Mahias, 1994).

2. The Green Revolution: Conservative Modernisation and the Marginalisation of Livestock

To achieve food self-sufficiency, an ambitious agricultural policy was initiated soon after independence. A land reform seeking to remove intermediaries and secure land tenure was implemented in the 1950's. In the 1960's started the "Green Revolution" based on three main principles: (i) the spread of high yield potential varieties of cereals and chemical fertiliser at subsidised prices; (ii) public investment in infrastructure, particularly irrigation; (iii) the provision of services to farmers, specifically access to loans (Dorin & Landy, 2009; Boillot, 2009, John & Babu, 2021).

2.1. A Land Reform with Little Redistribution

The abolition of intermediaries like *zamindars* took place rapidly, with the first Five-Year Plan (1951-1956) and tax was sharply reduced. The Land Ceiling Act then established limits on the area a landowner could own, but the enforcement of this law varied from one state to another.

However, these new regulations only had a modest impact. Occupancy tenants, who no longer had to pay land tax and were now owners, found themselves in a better situation. A number of tenants-at-will, however, were driven out with no notice, by owners who feared they would lose these fields, and they were replaced by day labourers. State governments did not widely

apply the land ceilings and many *zamindars* benefitted from the ambiguities in the law (Ladejinsky, 1972). By distributing their land among family members, the landlords often maintained most of their land assets (Das, 2001). Although they lost their prerogatives over collective spaces (*saltus*), which became part of the public domain, they often maintained their *ager* fields. In Bihar, there were still properties as large as 100 to 300 ha after the reform (Singaravelou, 1986).

With the exception of Kerala and West Bengal, which under communist governments effectively applied agrarian reforms, land redistribution remained globally limited. Indian agrarian reform nonetheless contributed greatly to preparing the imminent Green Revolution. Average and well-off farmers saw an improvement in their situations as, following the “land to the tiller” principle, they became outright owners of the land they cultivated. These farmers were the first actors in the Green Revolution.

2.2. The Green Revolution and the Enclosure of the Ager

Achieving the yield potential of the new cultivars presumed wide availability of water. To start with, the State focused its efforts on collective equipment. In the plateau regions, dams were built in the 1960s and 1970s: Bhadar and Chhapparwadi-Lunivav in Gondal, Bhadra in Channagiri or Nagarjuna Sagar upstream from Vinukonda, but given the topography, it was only possible to irrigate a section of the areas and in some cases for only three or four months after the rainy season. During the same period, collective pumping stations were set up in the delta but they only enabled the irrigation of a part of the cultivated area.

In the plateau, delta and alluvial plain regions, it was mainly private equipment that made irrigation available to a large number of farmers, and clearly extended the irrigable area (Molle *et al.*, 2003; Aubriot, 2006; Shah, 2009). In the 1980s, farmers could buy mechanical pumps fitted with diesel motors that had a much higher output than traditional water lifting methods. Then, with the electrification of the countryside (with subsidised electricity for pumping in most States) and the spread of submersible electric pumps from the end of the 1980s, it became possible to create borewells that were several hundred feet deep.

By lengthening the cropping season, irrigation enabled a multiplication of the number of crop cycles, but it compromised the former crop-livestock associations. In the delta, to start with, where earlier a single crop cycle of rice was grown during the monsoon (*aman* rice), it became possible to grow two annual cycles. From 1980 onwards, dry season rice (*boro* rice) progressed very quickly (Raychaudhuri, 2004). In this part of India where rainfall is fairly high, irrigation completely abolished the constraints of the short dry season and makes the use of the fields as grazing areas during the dry season no longer possible.

When it comes to the plateau regions (Fig. 1), double cropping was sometimes practiced in areas that received rainfall from both southwest and northeast monsoons, as in Andhra Pradesh and Karnataka, but irrigation made this a systematic practice. Moreover, it became possible to grow very lucrative pluri-annual or perennial crops. Encouraged by an attractive pricing policy, sugarcane had its hour of glory in the 1980-1990s in Palamaner and Gundlupet (Fischer *et al.*, 2022). Since the 2000s, prices have fallen, and sugarcane was replaced by mulberry for silk-worms in Palamaner, banana in Gundlupet, and *Areca Catechu* spread in Channagiri. These pluri-annual or perennial crops meant that livestock no longer had access to the *ager*. Even in areas with short monsoon, the number of crop cycles increased. In Gondal, peanuts sown during the rainy season could be followed by a winter dry season crop of cumin, wheat or onions. Irrigation also permitted the development of a 6 to 8-month cotton crop in Gondal or Banaganapalli.

Finally, in the alluvial plains, irrigation had similar effects. In Bodhgaya, before the Green Revolution, monsoon rice was the main crop, grown in small areas located beneath traditional reservoirs (*ahar*). With the multiplication of borewells it became possible not only to considerably increase the rice growing area but also to grow wheat as a second crop at the beginning of the dry season. Animals hence continued to have access to fields, but the grazing period was reduced from 8 to 4 months. In Petlad, a single crop of rice or millet was the norm, apart from on the few fields irrigated with well water. Short cycle cultivars and irrigation made it possible to grow rice during the monsoon, tobacco in *rabi* and millet during the dry season. Fallow periods on these fields were hence reduced to just a few days. In

low-lying areas, banana plantations developed and these spaces were no longer accessible to animals.

In addition, irrigated crops that developed from the 1990s and 2000s onwards in the study areas provided lower quality residues for animal fodder than cereals, some pulses like groundnut, or even sugar cane, that they replaced. In some cases (tobacco, onions, mango), the residues are not comestible by animals. Given the decrease in dry season fodder, many farmers reduced their herds, only keeping a pair of draught animals (Kurup, 2001). With the simultaneous rise in mechanisation – observed in all the study areas to a lower or higher degree – some farmers have even completely abandoned draught animal farming. They first resorted to service provision for occasional interventions such as levelling fields then, little by little, ploughing with tractor became more frequent, particularly for the first crop cycle as the clayey soil could be extremely compact at the end of the dry season. As underlined for South Asia (Justice & Biggs, 2020), mini-tractors have become increasingly common in recent times, in Gondal or Bangaon for example. As they are light and easily manoeuvrable, they can completely replace animal traction.

In the areas where the pastoralists were present, their situation has become critical. In Gujarat, the Bharvar pastoralists have encountered increasing difficulty in taking their herds to graze on crop residues on farmers' fields (Cincotta & Pangare, 1994). In Gondal, for fear of seeing their cotton plants harmed, the farmers have installed thorny hedges, cacti, or barbed wire fences. Their own animals no longer graze on the *ager* but are fed on crop residues, which the farmers keep exclusively for their own use. Fertility renewal on the fields has become increasingly dependent on highly subsidised chemical fertiliser. Whether because of a reduction in grazing areas or the replacement of roles earlier played by livestock by inputs (chemical fertiliser) or equipment (tractors, pumps), livestock have been ousted from the *ager*. And with the increased use of chemical fertiliser, the *saltus* gradually lost one of its main functions.

2.3. The New Functions of the *Saltus*

In the alluvial plains where the terrain is fairly even, the new irrigation equipment made it possible to cultivate the *saltus*. This was not the case in the plateau areas where the rocky hills and foothills have remained inaccessible to irrigation (Fig. 2).

The distribution of a part of the former common pastoral lands that belonged to the public domain since the agrarian reforms, served to remedy the land inequalities that persisted in the countryside. Between the 1950s and the 1990s, land distribution programmes involving the privatisation of the former commons multiplied (Jodha, 1989, 1990). This is how some households in Gondal, Gundlupet and Channagiri acquired land during this period. Apart from their small size (0,8 to 1,5 ha per household), the holdings were located on rocky hills and in foothills, which required high investment to make them cultivable. Thus in Channagiri, apart from digging borewells, the levelling of the fields had to be funded, as well as the transportation by truck of sediments from the ancient irrigation tanks in order to artificially constitute a soil. It was hence extremely difficult for the beneficiaries, who had no capital at all, to valorise this unfertile land, and many soon sold it to farmers who had a larger financial capacity. Thus, whether it was in Andhra Pradesh (Jodha, 1990), Gujarat (Jodha, 1989) or Karnataka (Pasha, 1992), land distribution primarily benefitted the better-off households.

Apart from this occasional distribution, these former grazing areas were converted into forest (Dharampur, Channagiri) or animal reserves (Koundinya Wildlife Sanctuary in Palamaner, Bandipur Tiger Reserve in Gundlupet). Wood cutting and cultivation were then prohibited. Grazing was sometimes tolerated, but it often turned out to be incompatible with the presence of wild animals.

As a result, the land reform benefited landless households only marginally, and with the privatisation of the commons, their situation deteriorated. Deprived of a major part of their fodder resources, the pastoralists were the first victims of this process, but we should not neglect the importance of these areas for agricultural labourers and tribal populations: gathering, wood

charcoal production, small ruminant farming, were so many activities that earlier filled the off-peak periods in their work calendar.

2.4. The Green Revolution's Reserve Army

The new cropping systems that developed with irrigation were particularly labour intensive. The multiplication of crop cycles clearly increased the work invested in a single field, and higher yields led to more time being spent on harvest and post-harvest operations which for most of them have not been mechanised in the study areas. Furthermore, with better availability of water, there has been an increase in vegetable cropping systems with associated crops grown in succession that require intense manual labour. In the three study areas, labour requirements for irrigated cropping systems thus range from 176 to 940 work days per hectare per year compared with 112 to 269 for rainfed cropping systems. This intensification of labour was accompanied by a rise in labour productivity which explains the speed with which farmers who had the means implemented the new techniques promoted by the Green Revolution: the added value per work day varies between 340 and 3200 rupees (Rs)⁴ for irrigated cropping systems and between 250 and 490 for rainfed cropping systems (Fig. 4).

In all the study areas, the importance of hired labour, which is now based on daily wage labourers, is remarkable. The vast majority of farms make use of hired labour in addition to family labour (Fig. 5) and there are, in fact, few strictly family farms. Although they are even rarer, a few farms that only make use of hired labour do exist. Since the 1980s, investors from Kerala or Tamil Nadu have thus bought or rented land in Gundlupet to establish coconut groves that can be as large as 40 hectares. In Channagiri similar investments have been made in areca nut palm groves and in Vinukonda, in mango groves. In Petlad, dairy farms with about a hundred cross breed cows also function solely on the basis of hired labour (see 3.3).

4. Exchange rate at the time of the study was 75 rupees for 1 euro.

3. Resulting Inequalities: White Revolution and Dairy Farming as a Buffer?

The Green Revolution has contributed to sustaining and even exacerbating inequalities among farmers. In addition to land access, access to water became crucial. Wage labour opportunities exist on irrigated farms, but salaries have remained low. With the White Revolution, dairy farming became a crucial agricultural activity for marginalized farmers. But just as with crops, this production requires land and water to provide substantial income.

3.1. Inequalities Associated with the Development of Irrigated Agriculture

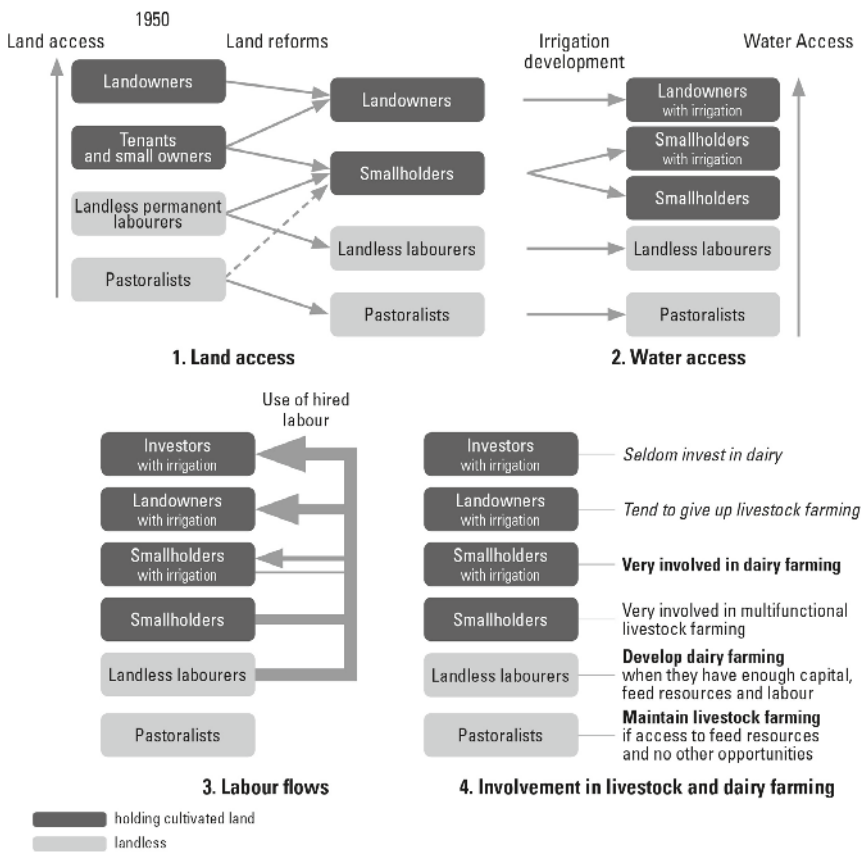
Although the agrarian reforms that preceded or accompanied the Green Revolution abolished land tax and secured tenure for farmers, in all the study areas they left some households landless (Fig. 3), and in some cases the latter are numerically predominant (in the two study areas in Bihar for example). In West Bengal, the agrarian reforms were certainly more effective, but land redistribution for the poor often involved land that is more difficult to exploit, and in this state with very high demographic density, many households did not benefit from the reforms. At the scale of India, the proportion of landless households in rural areas is estimated at 40% on the basis of NSS data (Rawal, 2008) and for the first time, in the 2011 Census, the number of agricultural labourers⁵ (144 millions) surpassed the number of cultivators (111 millions) (Dorin & Aubron, 2016). In addition to this limited access to cultivated land, access to common property resources was, as we saw, drastically reduced by the extension and closure of the *ager* and the conversion of the *saltus* into reserves.

These land inequalities are reinforced by access to irrigation, which is also unequal (Fig. 3). In the alluvial plains and the delta, groundwater irrigation is relatively easy (shallow borewells, large flow and hence few borewells per irrigated hectare) and covers a large part of the cultivated area. The situation of the plateaus with hard rock aquifer is very different: some mountain or hilly areas as well as sites located far away from the surface irrigation network

5. Agricultural labourers are defined in the census as workers whose main income is derived from working on other people's land and are not necessarily all landless.

in the study areas equipped with canals (e.g. Vinukonda) still do not have access to irrigation; where the farmers drilled borewells, they could easily draw water from the weathered superficial layer of the aquifer the first years, but with the drop in the groundwater table due to the excessive extraction compared to the recharge capacity, they have had to seek water at deeper levels that are far less productive (Boisson *et al.*, 2015). High investment in deeper and deeper borewells has become necessary for an uncertain result (Maréchal, 2010). This constitutes an additional factor of differentiation, as the better-off farmers are more capable of investing and capturing the water resources to the detriment of the others (Shah, 1989; Prabhakar & Aubriot, 2009; Srinivasan & Kulkarni, 2014; Fischer *et al.*, 2022).

Figure 3. Social differentiation factors in the study areas and investment in livestock farming



Source: Elaboration by the Authors, 2023.

A final aspect, far less discussed in research on the development of irrigated agriculture in India than the former two issues, contributes to reinforcing inequalities. This is the distribution of added value between landholders and agricultural labourers. As we saw, in all the study areas, hired labourers carry out a large share of the agricultural work, or even all of it on some farms. Now, the added value created by a day's work (labour productivity) in irrigated cropping systems is far higher than the daily wage agricultural labourers earn. In the three study areas presented as an example (Fig. 4), it varies between 340 and 3200 Rs per day of work, and is between 2.3 and up to 10 times higher than the local daily wage, hence most of the wealth created goes to the landholder. Although national statistics show a recent rise in agricultural wages (Das & Usami, 2017), the thirteen field studies show that given the way the added value is currently distributed, the labour force flows central to irrigated agriculture do not compensate, and in fact reinforce, the inequalities in access to land and water presented above (see figure 3, and for other examples, see Aubron *et al.*, 2015).

3.2. The White Revolution and the Diversity of Dairy Farming Systems

Like the Green Revolution, the White Revolution was the object of public policy. Depending on the regions, it took place more or less precociously: while it was launched in the 1960s in the centre of Gujarat, it only spread to the study areas in Bihar or the South of India in the 1990s or even the 2000s. In Channagiri (Karnataka), or Bangaon and Hirbandh in West Bengal, it still has a very marginal presence. Everywhere it associated two series of changes related, on the one hand, to the sale of milk and, on the other, to its production. It began with the former, with the establishment of collection systems that created an outlet for the daily sale of their milk production for livestock farmers. The cooperative collection, processing and marketing system for dairy products, supported by the NDDB, exists in the thirteen study areas and is particularly well established in the state of Gujarat, where it was born (Dervillé *et al.*, 2019). In some areas, it coexists with informal milk collection channels (Staal *et al.*, 2006; Kumar *et al.*, 2011), or private dairies, since the termination of exclusive cooperative collection areas in 2003 following the liberalisation of the sector⁶ (Scholten & Basu, 2009;

6. For an analysis of this process in two of the study areas (Palamaner and Vinukonda in Andhra Pradesh) see Jénin & Dervillé, 2019.

Birthal *et al.*, 2017). The changes related to milk production impelled by the White Revolution are changes in animal genetics and livestock practices, targeting an increase in milk production. Cross breeding with breeds with higher milk yields (Holstein, Jersey, Gir for cows, Murrah for buffaloes) was facilitated by artificial insemination carried out by cooperatives, the State, NGOs, or private structures, which is today the dominant mode of reproduction in all the study areas. Animal nutrition was transformed by the development of fodder crops (napier, sorghum, maize, berseem, etc.), the circulation of straw (rice and wheat from the Green Revolution) and the marketing of industrially produced concentrates (containing cakes, bran, grains, molasses, etc.). Animal health management has also changed with a rise in vaccinations and prophylaxis⁷.

At the technical level, the diversity of dairy farming systems in the thirteen study areas is first structured by the genetic type of the animals: cattle or buffalo, breed and level of cross breeding. The size of the herd is a second factor: the vast majority of herds consist of only one or two cows or female buffaloes, in line with the national average shown in the Livestock Census (Government of India, 2012), but larger farms – one to about a few dozen females – exist in some of the study areas. Finally, feeding practices play a role, with a variable combination of feed resources: (i) natural fodder, grazed or collected daily, growing on what is left of the *saltus*, on the *ager* during cultivation (weeding) or after the harvest, or on the edges of paths and fields; (ii) fibrous crop residue (like straw) that can be produced on the farm or bought; (iii) cultivated fodder, often irrigated, cut daily and distributed to the animals; (iv) purchased concentrates. Among the systems studied, the milk yield varies between 150 l per cow per year on farms with mixed local dairy and traction breed almost entirely fed on natural fodder (Dharampur mountains, Gujarat) and 2500 l per cow per year for stall-fed Holsteins that receive a daily ration consisting of green cultivated fodder, rice straw and purchased concentrates (Ekangarsarai, Bihar).

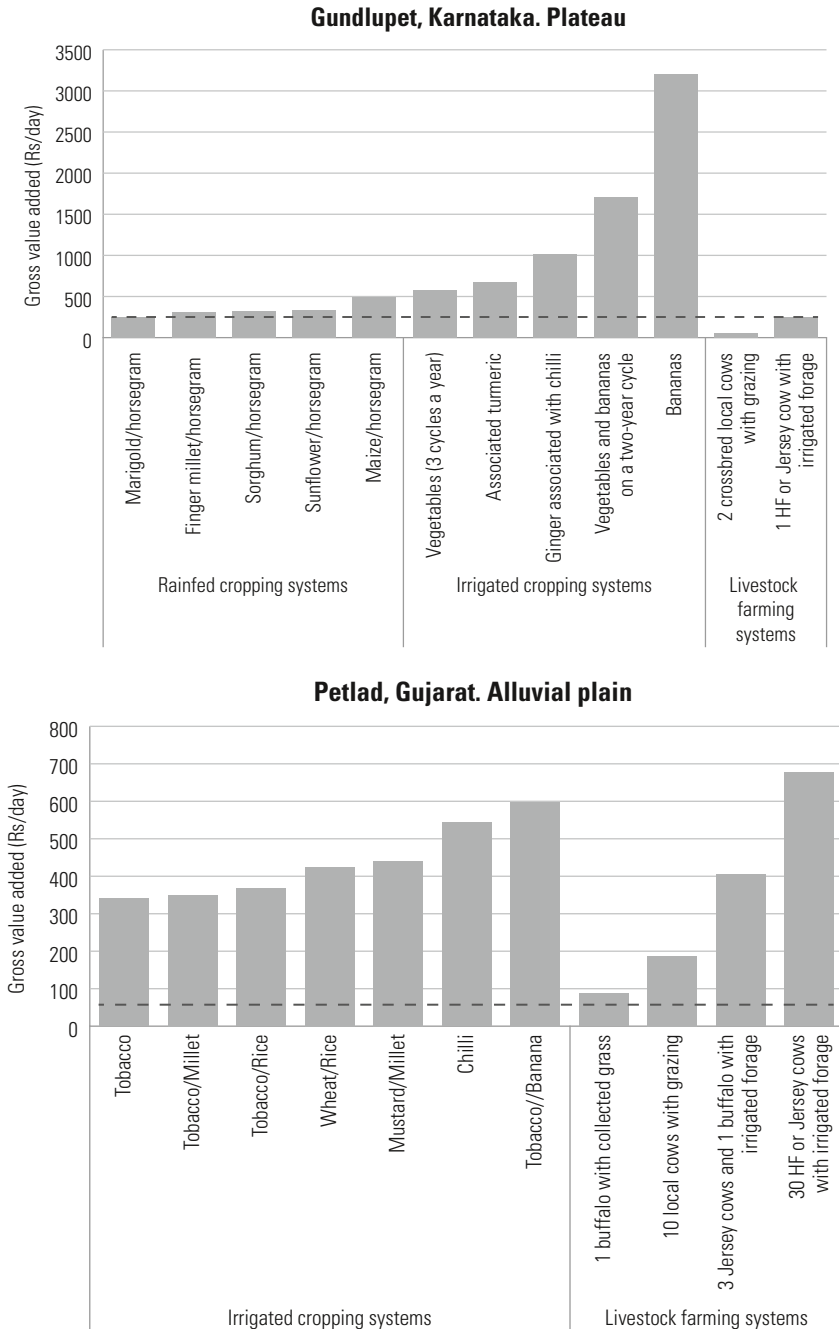
7. Regarding meat from the dairy herd, bans on the slaughter of cattle are in place in most Indian States. However, these do not usually apply to buffalo and India has thus become a major exporter of buffalo meat in the 2010s.

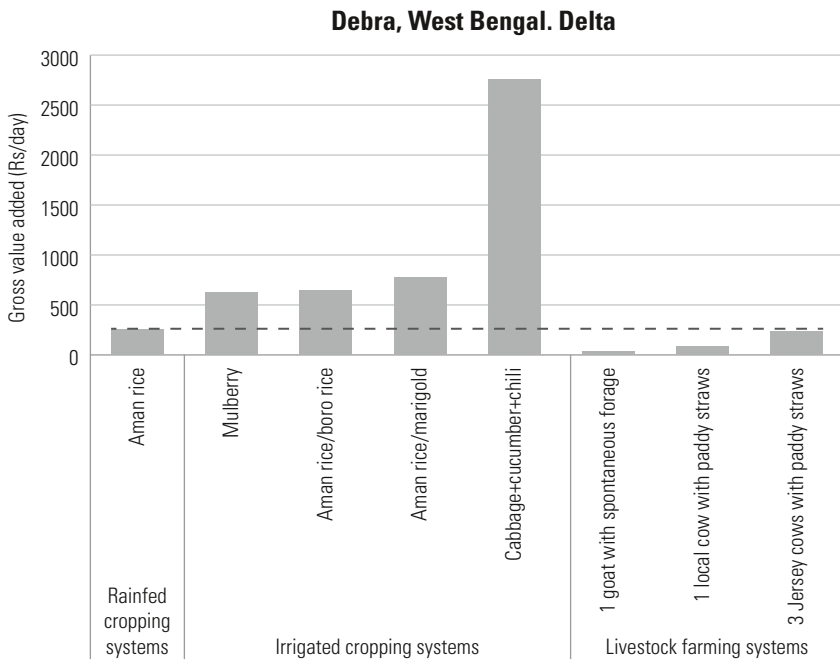
3.3. Differentiated Investment in Livestock Farming and Remuneration

In the thirteen study areas, the investment in farming activities is not uniform, depending on the social categories. To start with, the landowners who own the most land and have the highest access to water tend to abandon livestock (Fig. 3). As they use purchased fertiliser and have a tractor, they no longer have an absolute need to own animals. Furthermore, as figure 4 shows, livestock farming creates less added value per work day than many other irrigated cropping systems that these owners can engage in. The wealth that livestock farming creates, is sometimes not even enough to pay the labour at the local daily agricultural wage (labour productivity for livestock lower than the daily wage, this is the case of the four livestock farming systems in Debra, in the delta, for example, figure 4). Under these circumstances, some owners maintain one or two cows or female buffaloes, and their products (milk, dung cakes in Bihar) are sometimes entirely intended for family consumption. Others, particularly when they have reduced family labour to ensure the livestock farming work (relatively old parents, whose children have settled in towns), tend to abandon livestock farming and focus on more profitable irrigated crops.

In nine of the study areas, there are large dairy farms with a few dozen females looked after by hired labourers. They show the opportunities to increase labour productivity in dairy farming, and the conditions required for this increase (figure 4 shows the example of a farm with 30 cows in Petlad): genetic type with high milk yield, stall-fed with green cultivated fodder, straw and purchased concentrates, and a large herd that permits economies of scale in terms of work. Nonetheless, apart from Petlad in Gujarat, located within the perimeter of the oldest cooperative's (Amul) collection area, where a few dozen farms of this type operate, such farms are so far numerically insignificant elsewhere (one or two per study area): there are more investors in irrigated crops with no livestock activity, which are just as, if not more profitable.

Figure 4. Comparison of daily labour productivity in the main cropping and livestock farming systems in three study areas





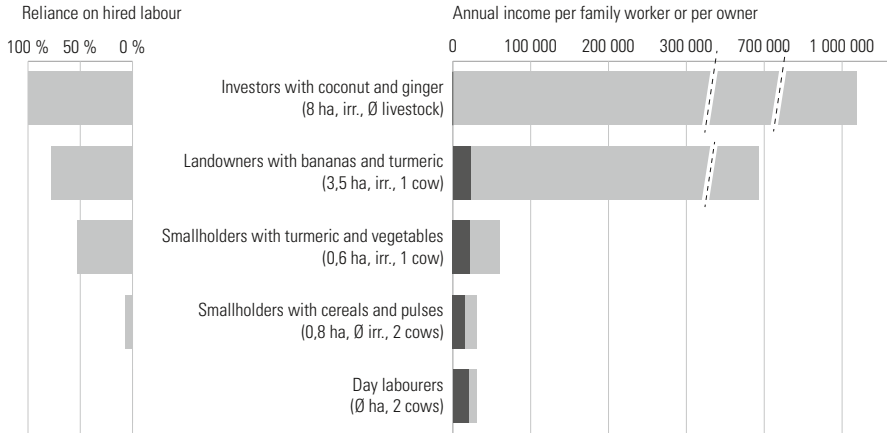
Legend: The Gross Value Added is equal to the difference between the value of goods produced (including goods that are self-consumed by the family, e.g. milk, and non-food products like manure or draught power) and that of goods or services entirely consumed during the production cycle. The daily labour productivity is equal to the value added divided by the number of work days invested. See Cochet (2015b) for more details. The dotted line corresponds to the local daily wage a labourer earns.

Source: Elaboration by the authors based on Lucas, 2014; Fischer, 2016; Tessier and Taghavi, 2019.

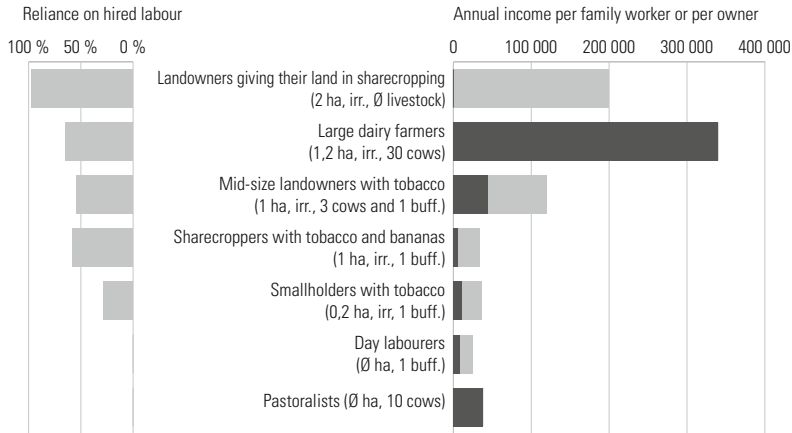
The rest of the social chessboard is, for its part, massively involved in livestock farming (Fig. 3). This is primarily true of smallholders, particularly when they have no access to irrigation and are still highly dependent on the roles livestock play in terms of draught and fertility management (Erenstein & Thorpe, 2010; Basu & Scholten, 2012; Cochetel *et al.*, 2019). For them, just like for the landless agricultural labourers and pastoralist communities, livestock farming is also a means of supplementing an agricultural income, which is lower than that of the large landowners and investors as they have less access to land and water. But the types of livestock farms established and the economic results obtained are also very different depending on the social category. Only farmers who have access to water can cultivate irrigated fodder and thus support their animals' dairy production in every season.

Figure 5. Use of a hired labour force, income from agriculture and contribution of livestock to income for the main production systems in three study areas

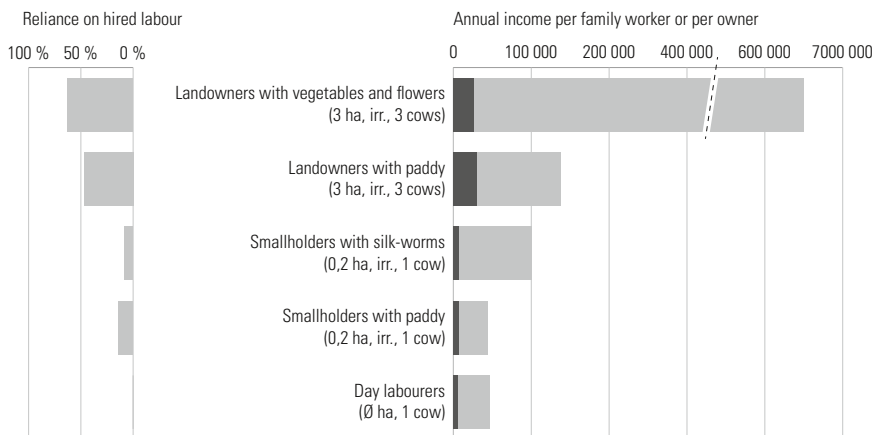
Gundlupet, Karnataka. Plateau



Petlad, Gujarat. Alluvial plain



Debra, West Bengal. Delta



Legend: Agricultural income is the share of net value added left to the farmer after the other economic agents who have contributed to providing access to the means of production in this type of farm have been paid (Cochet, 2015b). Land rental, wages for hired labourers, interest on loans and taxes, are thus deducted from the value added where applicable. Other income linked to agriculture (daily wage as a farm labourer on other farms, for example) is included in the calculation of the total income when applicable. Source: Elaboration by the authors based on Lucas, 2014; Fischer, 2016; Tessier and Taghavi, 2019.

Farmers with no access to irrigation water generally combine natural fodder and straw from their fields. Landless agricultural labourers who raise animals and pastoralists, who for their part only have access to straw if they can buy it (or exchange it for work, a common practice for the former), hence mainly use natural fodder to feed their animals. Now grazing areas, as we saw, are more limited than in the past and the manual collection and transportation of natural fodder (weeding the *ager*, collection on the edges of fields and paths) are labour intensive activities, all the more so as fodder resources are located far away and are dispersed. Animals fed on natural fodder also tend to produce less milk. Daily labour productivity on farms that make use of natural fodder is thus far lower than on those using green cultivated forage or even straw as the main source of fodder. In the cases presented in figure 4, it varies from 53 to 187 Rs per work day, and in most cases, it is far lower than the local daily agricultural wage.

Thus livestock farming labour productivity is all the lower as access to resources (land, water, fodder) is limited, while it is precisely these circumstances that force people to supplement their income with livestock. This paradox is visible in figure 5: the contribution of livestock to agricultural income is higher for the social categories that have limited access to resources, but the income generated in this manner, close to the poverty threshold of 30 000 Rs per worker per year, remains very low in comparison to the income from irrigated agriculture.

Conclusion

First of all, this research confirms the results of two earlier series of studies. A first series of studies underscored the differentiating effects of the Green Revolution, which we recall here. Far from being limited to mere technical transformations, the changes that took place in the Indian countryside over the course of the last decades provoked dramatic changes not only between regions, but also between categories of farmers. This phenomenon has been widely studied in India (Das, 1998a, 1998b, 2002; Dhanagare, 1988; Yapa, 1993; Rao, 2005) as well as in other countries in the world (Freebairn, 1995).

A second series of studies highlighted the benefits of the White Revolution for the poorest rural households. And indeed, in all the small regions studied here, dairy farming is mainly practiced by farmers with little land, or sometimes landless farmers. This activity provides an essential income as underscored by other authors (Candler & Kumar, 1998; Kurup, 2001; Kurien, 2004; Akter *et al.*, 2008; Birthal & Negi, 2012; Nair & Krishnakumar, 2014).

The originality of the current research is integrating these two series of results into a systemic approach and thus providing a new interpretation of the changes that have taken place. The Green and White Revolutions were not parallel processes with the latter compensating the drawbacks of the former, they are in fact indissociable.

To start with, this is due to their common origins. Beyond geographical specificities, the agrarian systems that prevailed in the 1950s in each of the small regions, associated large landowners and small tenants, crop and livestock, cultivated and grazing areas. The Green Revolution affected all the elements that constitute agrarian systems. It was more beneficial to mid-size and large landowners and left behind smallholders; it rejected livestock farming to the benefit of crops and extended the *ager* at the expense of the *saltus*. The White Revolution, for its part, brought the losers together, and dairy farming practiced on limited areas thus seems to be the default choice of those who benefitted the least from the Green Revolution. In addition, one of the key results of the present study is that even when it generates income, dairy production does not seem to be an effective route out of poverty. Dairy farming proves to be far less profitable than irrigated crops. Labour productivity only seems to reach comparable levels when it is possible to feed more productive and a relatively higher number of animals, or in other words, when sufficient irrigated land is available.

Then, they are indissociable in the way they currently work together. In the literature, the Green and White Revolutions are often presented as linked by the flow of matter between crops and livestock, particularly in terms of crop residues (Erenstein & Thorpe, 2010; Amarasinghe *et al.*, 2012; Rajan & Shah, 2020), as well as by the security the combination of these activities provides for the household economy (risk management, treasury and investment, regularity and complementarity of incomes, etc.) (Scholten & Basu, 2009; Erenstein & Thorpe, 2010). This article confirms these links, but make it possible to take the interpretation of this connection further by integrating the division of labour into the analysis. What the study of production systems in these small regions underscores is that the Green Revolution in India was indeed a vast process of intensification thanks to hired labour. The wage level in rural areas is a delicate issue in India: in a farming model that has recently been referred to as “patronal” (Aubron *et al.*, 2022), it conditions not only the payment of the poorest, but also the remuneration of a large number of farmers who are also employers. The recent debates around the National Rural Employment Guarantee Act (NREGA) confirm the importance of this subject. With this programme, the State committed to providing at least 100 days of paid employment for every poor household.

Since it was launched in 2005, this policy has been the object of multiple controversies. For some authors, it has no impact on wages (Zimmermann, 2012). For others, it has contributed to raising the cost of labour (Berg *et al.*, 2018) and is also said to have led to reducing the availability of labour in rural areas due to migration to other sectors (FICCI, 2015). On its own, the income from dairy production is insufficient, but added to their wages it allows agricultural labourers to provide for their families. The White Revolution thus seems to be an indispensable supplement to the success of the Green Revolution. Like the programme subsidising basic food products (public procurement of cereals and Public Distribution System) it has contributed to keeping agricultural wages low, at least until recently (Das & Usami, 2017), with the specificity of retaining this labour force in rural areas. In a context where public intervention in the cereal market has been recently called into question with three farm laws that were strongly contested by large-scale protests until their repeal at the end of 2021 (Jodhka, 2021; Landy & Dorin, 2022), the stabilising role of dairy farming could become even more crucial.

The link between the Green and the White Revolutions, a combination of exclusion and inclusion finally seems extremely coherent: it has permitted an increase in productivity in the agricultural sector, without deeply transforming the distribution of land and by limiting the rural exodus. This coherence should be taken into account in the future. Scholars have long been concerned by the low productivity in the Indian dairy sector, whether in the already old interpretation of the persistence of numerous little productive animals as a “surplus” (Dandekar, 1964) or when they more recently underscore the relevance of the increase in animal productivity to fulfil the national demand for milk (Gautam *et al.*, 2010), increase smallholders’ incomes (Birthal & Taneja, 2012), or reduce environmental impacts (Gerber *et al.*, 2013; Patra, 2017). Intensification techniques are already available (artificial insemination, fodder crops, purchased concentrates...) but what the present research shows is that they can only be implemented by certain farmers, and are very likely to exclude those with limited access (or none) to land and water. Apart from imagining low-cost distribution of feed blocks that would complete the transformation of these livestock farms into off-land farms, farmers with little land and water are, in fact, often incapable of accessing the necessary feed – both in terms of quantity and quality – to

feed high milk yield animals. The tension between animal productivity and the inclusiveness of the dairy sector, between “productivity and participation” (Scholten & Basu, 2009), is certainly described in certain studies (Sharma *et al.*, 2002), underscored as a surveillance point (Scholten & Basu, 2009; Nair & Krishnakumar, 2014), or drawn upon to question the relevance of the intensification of livestock farming in yet others (Ramdas, 2018), but it is missing in most works on livestock farming in India, although it has major consequences in terms of support policies. Implementing techniques to increase animal productivity would be very likely to endow the White Revolution with the same selective drawbacks as the Green Revolution. It is the coherence of the Indian agricultural development model in terms of employment and territorial development (via a regulation of the rural exodus) that would then be under threat. Is the recent promotion of agroecology and natural farming (Khadse *et al.*, 2018), which marks a revival in the use of animal excreta (dung and urine) for crop production in India, likely to foster this integrated approach of livestock and agriculture?

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Recent publications

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