



Environment & Society Portal



The White Horse Press

Full citation:

Mann, Michael. "Ecological Change in North India: Deforestation and Agrarian Distress in the Ganga–Jamna Doab 1800–1850." *Environment and History* 1, no. 2 (June 1995): 201–20.  
<http://www.environmentandsociety.org/node/2833>.

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# Ecological Change in North India: Deforestation and Agrarian Distress in the Ganga-Jamna Doab 1800-1850

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## SUMMARY

The British were not the only foreign rulers to bring ecological catastrophe to India. Large areas of forest had been destroyed under the Moguls in the 17th century. The Moguls' former hunting grounds west and south west of Agra had disappeared by 1800. That the residency in Fatehpur Sikri was deserted after the wells had silted up was a further clear indication of this deterioration. Yet the reasons for this overexploitation differed greatly from those of the British rulers.

It can be assumed that it was demographic pressures which led to forest clearances in the 17th century. Timber was needed to build new houses and even towns, whose citizens in turn needed firewood, and land to cultivate. In the context of the transformation of Indian agrarian structures by the colonial rulers, totally different mechanisms were in operation.

- Until 1835 the revenue rate in the Ceded and Conquered Provinces was over three quarters, only being reduced to 'half the net rental assets' after 1855. Only then did the revenue rate again match that in force under the Moguls, although its flexibility was still not as great.
- The market for land created by the British laid a value upon the soil making it a tradeable commodity. Whilst there had been some limited private property in pre-British times, land had not been a marketable asset.

These two prerequisites put in place by the colonial rulers set the ecological catastrophe in motion. For the peasants, a vicious circle of revenue and debt payment, cash crop plantation and permanent acquisition of new land was created just to meet the new demands. Forests were cleared to gain new land for cash crops, whilst cultivation of food was increasingly marginalised. Ever greater demands were put upon the soil, hardly leaving time for its regeneration and in many parts of the Doab, but particularly in the Agra Division in the second half of the 19th century, it was totally exhausted. This change was completed within more or less 25 years (1805-1830). The devastation of the ecology of the

Doab, which manifested itself so appallingly in 1837-38 led to the impoverishment both of large sections of the population and of the region.

## INTRODUCTION

This paper offers an example of the consequences of human intervention into pre-existing natural conditions, and the resultant deterioration in general living standards in a specific region. Ecology can be defined as the relationship between living organisms and their environment, or a set of relationships between a particular organism and its environment. It is important to note that this is not only a 'bilateral' but a 'multilateral' interactive paradigm.<sup>1</sup> In this paper the emphasis will be upon human ecology, the relationship between human groups and their physical environment. I shall, however, reject the implied human-centredness of this approach.

The activities of human beings in their habitat can often lead to extensive changes in what had previously been an ecological equilibrium. This balance differs according to geographical, geological and climatological conditions and involves similarly diverse functions of flora and fauna. Natural catastrophes such as volcanic eruptions, droughts, floods, and storms can cause lasting imbalance within a relatively short period but in the long term, natural self regulating processes can re-establish a highly developed and richly varied natural environment.<sup>2</sup> Large scale permanent change, restructuring and damage to the environment, and thus to the ecosystem is more often the result of human interference. To a certain extent this happened and continues to happen through ignorance. People have often had to give up their place of habitat as a consequence of environmental changes which they themselves had caused. They had destroyed their own ecological niche; an achievement seldom paralleled by other living species. Today, such developments are particularly frequent.

Serious environmental damage and an increased malfunction of ecosystems frequently appeared in the tracks of European expansion to Asia and America. In the 'New World', it has been argued, the arrival of the Spanish and Portuguese, followed by the North Europeans, saw the almost total collapse of a hitherto largely balanced ecological environment. New species of animals, plants, bacteria, and viruses which the Europeans both wittingly and unwittingly brought with them caused a far-reaching ecological transformation. The death of plants, animals and people on a massive scale was an unavoidable consequence.<sup>3</sup>

European presence in Asia at first caused only an enormous increase in country trade. In the struggle for dominance between the East India Company (EIC) and the Vereenigde Oostindische Compagnie (VOC) from 1720-40 the British emerged victorious and controlled the major part of Asian trade (excluding Japan). European conflict between Britain and France from 1744 (until 1815) led to the development of British territorial rule, in particular over large parts of

India. From the mid-17th century, country trade and up-country trade made territorial control by the trading companies appear advantageous. The reasons for the eventual British eclipse of the *Compagnie des Indes* cannot be discussed here. The colonial wars in India and the EIC's territorial annexations brought it control not only of cash crop production (cotton, sugar cane and indigo), but also of the associated revenues from agriculture. Thus not only the wars but also the EIC's trade with China came to be locally financed, gaining the company independence from London's exported silver. These EIC ambitions soon developed their own dynamic which degenerated into a hunger for land revenue. High revenue assessments and the permanent desire for expansion of 'more valuable crops', i.e., cash crops, led within a few decades to substantial ecological changes in large parts of British India. Such was the case in the Doab of Ganga and Jamna.

European expansion brought with it a new level of environmental destruction. From the mid-18th century onwards colonial commerce was characterised primarily by the export of raw materials. As mentioned above, this could only become profitable in combination with territorial control of the productive areas. In this context the plantation of cash crops was only worthwhile on a large scale with the aim of achieving and maintaining low costs for the raw materials produced. This could be achieved either through the introduction of the plantation economy, which by itself was uneconomical, or through the increase of land revenue, as the EIC showed in unique fashion in India. The Indian peasants in the Doab remained 'independent' producers who, saddled with increased revenue demands, were obliged to sow ever more of their land with 'more valuable crops' which commanded higher prices than food crops both on local and world markets. The dependence of the agrarian economy had been achieved by more or less subtle means; questions regarding the condition of the people, the soil, the flora and fauna of the intensive agricultural system did not at first concern the EIC.

Vehement and comprehensive criticism of the consequences of dependent commercial systems is not uniquely a product of developing ecological consciousness since the 1970s. After his stay in South America (1795-99), Alexander von Humboldt drew attention to uncontrolled colonial commerce which functioned at the expense of the climate, the water supply of entire regions and ultimately of the indigenous population. When Humboldt wanted to travel to India at the beginning of the 19th century the EIC Court of Directors refused him entry, rightly fearing that he might come across the first signs of fundamental deterioration of the environment and of ecosystems.<sup>4</sup>

But ecological awareness grew in Europe, or at least in the universities' medical faculties. Doctors effectively became observers of nature or even natural scientists. The notes made by these medics are invaluable sources for ecological history, because they sprang from an avowedly humanitarian desire to recognise and comprehend the human environment. Descriptions of the

countryside and changes of surroundings were necessary by-products of their research.<sup>5</sup>

Such material is by no means unscientific or unscholarly. Although one might accuse these researchers of working without statistics (which is in fact only partially true), it should be remembered that the natural sciences were then only just emerging from 'Naturphilosophie', and descriptive analysis was in any case far more in keeping with academic custom than were purely quantitative methods. There can be no justification for disregarding qualitative reports of climatic change, rising temperature and soil deterioration with the argument that these phenomena cannot be proven without 'empirical' measurements.

Contemporary results of natural scientific research should be taken seriously, especially when they can be substantiated by individual scholarly examination today. Conclusion by analogy can also be justified. The results of research into soil deterioration following deforestation in Africa in the second half of the 20th century cannot of course simply be transferred onto a similar process in north India in the first half of the 19th century. But it remains an important fact that following forest clearance the strength of light falling on the soil's surface increases, leading to a reduction in seed germination and plant growth. If geological and climatic conditions are similar to those in present-day Africa, a fall in the water table soon follows, and there is a decline in total precipitation. These effects are sufficient to enable analogies to be drawn.

It is also noteworthy that ecological knowledge today has progressed so little beyond the levels of 1850-60. Only when natural resources appeared threatened in the early 1970s, beginning with the lasting primary supply of oil for the industrialised world did a renewed academic interest develop, one which is now turned predominantly towards the tropical rainforests.

## GENERAL ECOLOGICAL PRECONDITIONS

Vegetation is a determining factor for both climate and environment. In every region of the planet forests regulate the climate and the availability of water. The following four points will indicate the vital interdependence of vegetation, water supply and climatic conditions.

1. The roots of trees, their depth and breadth varying according to species, keep the ground soft and provide an ecological niche for innumerable small creatures. 'Ideal soils consist of a mixture of living organisms and a variety of non-living components. This mixture is not random, but is highly integrated and has a precise architecture.'<sup>6</sup>
2. Forests have a decisive influence upon the level of precipitation, its effect, and its proper use by the soil. Areas of forest cause the rate of precipitation in a region to rise by up to 20%.<sup>7</sup> It can be established that in the tropical rain

forest of the Amazon region half of all rainfall stems from evapotranspiration from the vegetation and that the rest arises from evaporation of the sea.<sup>8</sup> The new growth of trees, bushes and grasses, as well as moss and herbs contributes substantially to the ground's water storage capacity, the roots of the vegetation offering the necessary channels in the forest's soil. This process is known as the 'sponge effect'.<sup>9</sup>

3. Areas of forest also regulate the temperature. Temperature is greatly reduced by the evapotranspiration of trees, and areas where there is a layer of plant covering have considerably higher levels of evaporation than bare soil, the latter drying out slightly as the absence of roots prevents water being channeled to the surface. The highest temperature is at the uppermost layer of plant growth and plants' poor conductivity prevents the heat being passed on downwards.<sup>10</sup> Measurements of temperature on bare soil in Africa have on occasion read over 65°C. If, however, there is enough vegetation to provide a pleasant level of shadow, the temperature sinks to 38°C. Soil covered with a layer of mulch experiences a lower temperature range between day and night than soil sown with cash crops. Coffee plantations in Tanzania register swings of up to 12°C, whilst those of mulch-covered soil remain within 2-3°C. Even light tree cover, of the kind we believe to have existed in parts of the north Indian *jangal*, substantially reduces the amount of direct sunlight falling on the soil, thereby keeping its temperature down. This is especially important for young plants and seedlings. The colour of the soil also plays a role, with light soil generally remaining cooler than dark soil.<sup>11</sup>
4. Finally, all kinds of vegetation help prevent erosion. After forest, grass cover is the most important. Both these types of vegetation provide almost total protection from erosion. Any change in the vegetation, by deforestation or breaking up grasslands in the most extreme cases, has an effect upon the soil's tendency to erode and the level of its mineral content. There is a distinction between water and wind erosion.<sup>12</sup> The former can lead to channel erosion in valleys or on gentle slopes, meaning that river sources can ultimately be blocked or waterways obstructed. Water erosion causes the loss of the top soil and thus of the soil's fertility, resulting in a dramatic drop in crop yield.<sup>13</sup> Wind erosion does not occur so frequently, but has more serious consequences. It only occurs in areas of dry soil and sparse vegetation. It can easily lead to sand and dust storms given strong enough 'push and pull' winds.

This great quantity of atmospheric dust influences the energy exchange pattern. The albedo of these particulates is higher than that of the vegetated ground surface, and so it reflects a greater fraction of incoming radiation back to space. Another fraction is absorbed by the particles themselves, warming the layer in which they are

suspended instead of the ground surface. At night these particulates act as a dusty blanket and reduce radiative cooling of the ground surface. The combined effects of these changes in the radiation balance seem to reduce the development of atmospheric instability that is essential to induce convectional rainfall. Heating of the atmospheric system as a whole is reduced, and the ground-level heating that can form bubbles and columns of intensely heated air is weakened. Hence, although there is enough moisture present to produce appreciable rainfall, the conditions that induce it are absent.<sup>14</sup>

Serious cases of erosion seldom occur naturally. They are often the direct consequence of forest and grass clearance. If no counter measures are taken, their effect increases, as well as the relative difference between wet and dry seasons. This is particularly so in climatic border zones such as the semi-arid areas prevalent south of Delhi in large parts of the Ganga-Jamna Doab. The transformation of forest, shrub- and grassland into heavily worked agricultural land, with an ever increasing proportion of cash crops thus leads, in this context, to a considerable loss of soil fertility. 'Natural ecosystems are self-regulating and self-perpetuating, and they display considerable temporal continuity, especially during the late state of succession. Most agroecosystems, particularly intensively managed monocultures, are neither self-regulating nor self-perpetuating.'<sup>15</sup>

#### LARGE SCALE AGRICULTURAL LAND DISTRIBUTION IN THE DOAB

From the foothills of the Himalayas, the Ganga and Jamna flow parallel to each other for almost 500km, separated by 80-120km of land. This Doab only starts to narrow once it passes south east of the town of Etawah, with the rivers finally joining in Allahabad. The people of the Doab distinguish between the river basin or *khadar* and the inter-fluvial lowlands, or *bangar*, considering them totally different areas.<sup>16</sup> The '*bangar* plateau' generally lies around 5-10 metres above the *khadar* and is bordered by the sandy embankment of the *bhur*. Between *bhur* and *bangar* is found the *bankati* area or clearance land,<sup>17</sup> that was first used for agriculture during the 19th century.

A protracted basin about 20-30km wide extends along the Ganga-Jamna Doab from Muzaffarnagar beyond Etah and Mainpuri. These so called Central Lowlands with their lowland clayey loam differ radically from the higher *bangar* plateau, the so called Western and Eastern Uplands and the adjoining *bhur* sand strip. During the monsoon season drainage flows from the uplands into the lowlands follow the large bends of the rivers Kali Nadi, Sirsa and Isan. Today the drainage channels no longer suffice and the Central Lowlands are often flooded. Viewed in profile, the natural land composition of the upper Ganges

plateau appears as a regular set of long narrow strips running parallel to the rivers.<sup>18</sup> But the main contrast is not in the relief but in the soil type and the hydrographic conditions. In the course of thousands of years of agricultural activity in the Doab highly refined farming and irrigation methods have been developed, which are appropriate to the area.<sup>19</sup>

Agricultural developments in the Doab since the British established their rule in 1801 have brought dramatic change, harming the soil, the water supply, plants, animals and people. The Doab's sensitive ecological system, in particular the part south of Delhi as far as Kanpur, was permanently damaged during the first thirty years of the 19th century. The move from food crops and sustainable subsistence farming to soil-intensive cash crop production, and the clearance of large areas of forest and grass *jangal* to extend the crop area was crucial. Ravaged agricultural areas, salinisation and serious erosion have resulted in desertification in large parts of the Doab.

#### NORTH INDIAN AGRICULTURE AROUND 1800

When the East India Company annexed the Ceded and Conquered Provinces at the beginning of the 19th century it gained one of India's most productive agricultural regions. Under the Moguls this area had been amongst the most intensively worked land in North India, and revenues were high. The increasingly powerful Jats had gained a further rise in agricultural productivity, and thus in revenues, in the second half of the 18th century.<sup>20</sup> Internal power struggles in North India at the end of the eighteenth century and the second Anglo-Maratha war led the Ganga-Jamna Doab into an agricultural crisis. It is well known that British historiography describes this area of land generally as impoverished, deserted and largely unproductive.<sup>21</sup> Yet examination of primary sources from the turn of the 19th century reveals another, and a far more precise, story.

The Doab's most notable natural feature was its forest. In the Upper Doab centuries of farming and the irrigation projects carried out under the Moguls had already severely reduced its area, but the Central and Lower Doab from Bulandshahar to beyond Kanpur, the interfluvial lowlands, was thick forest until the beginning of the nineteenth century. This forest belt of about 200km by 30km was partially impenetrable in the districts of Aligarh, Etah, Mainpuri and Kanpur.<sup>22</sup> The often extensive belts of forest around the towns were particularly notable. Bharatpur, Mainpuri, Aligarh, Shamshabad, Sikandra Rao and Kasganj are just a few examples.<sup>23</sup> Much of this forest was *dhak-jangal*. Where the land was cultivated, *dhak* trees grew on their own, or in groups on the grass-*jangal*. Forest covered at least 20% of the Doab.

In large parts of the Doab, intensive and highly productive farming continued at the beginning of the 19th century, although the disruption of war from 1803-

1805 had caused a temporary slump. The drought of 1803-1804 and the storms early in 1805 were further blows for the agricultural economy. The Grand Army's grain requirements in the Doab and its ban on imports from Rajasthan caused famine and a general desertion of the land by the civilian population. Reports of fallow fields and deserted villages are therefore hardly astonishing.<sup>24</sup> Yet it is precisely the fertility of the Doab which is emphasised by British officers advancing through the region. The agricultural economy was particularly healthy in the two large river valleys. From Bulandshahar District to beyond Mathura there were highly fertile fields along the Jamna. The small Doab of Chambal and Jamna was also known for its intensive agriculture and the Rajas' lands from Hathras and Mursan, those of the Begam Samru<sup>25</sup> and the areas around Aligarh and Coel were similarly fertile.<sup>26</sup>

The Ganga valley was well known for its high productivity of agricultural goods especially in the Farrukhabad area. Agriculture along the Ganges also included the cultivation of cash crops, predominantly indigo and sugar cane.<sup>27</sup> On the road from Farrukhabad to Aligarh via Kasganj, Sikandra Rao and Sasni the number of wells was particularly remarkable.<sup>28</sup> This evidences a still functioning agricultural infrastructure. Naturally the British officers only recorded what they saw either side of them along the road, but a network of routes can be reconstructed with primary sources which both confirms and extends these accounts.

The East India Company wanted to introduce a permanent settlement of the land revenue as quickly as possible in the Ceded and Conquered Provinces. The various merits of a Rayatwari versus a Zamindari settlement were considered in a discussion of English revenue theories in India. These Anglo-Indian revenue models could not, however, be applied to the newly annexed areas, but since Calcutta was pressing for a rapid and permanent settlement a survey of current and potential agricultural production was made. This task was entrusted to the revenue commissioners R.W. Cox and H. St. George Tucker, who on September 7th 1807 sent a circular to all revenue collectors in the Ceded and Conquered Provinces, asking them to check the readiness of their districts for the introduction of the permanent settlement.<sup>29</sup> The various districts proved to have different levels both of fertility and cultivation. Farrukhabad District was considered insufficiently developed but it still had large areas of fallow land. Only the Parganas beside the Ganges were thought fertile and able to sustain all crop types.<sup>30</sup> In Etawah District (where the drought of 1803-4 had been most severe) the land economy was on an altogether lower level. Yet the land was worked at a level proportionate to the density of population it sustained. The revenue collector also considered the land to be fertile and, in the case of population growth, ripe for expansion through *jangal* clearance, drainage of wetlands and fertilisation of infertile land.<sup>31</sup> The agricultural condition of the Agra District produced this well known comment:

## ECOLOGICAL CHANGES IN NORTH INDIA

The district is in general well cultivated, and not very great further improvement can, I think, be expected either from the cultivation being extended or from the introduction of the cultivation of more valuable articles than what are already produced. The population is by no means deficient, and the Zamindars for the most part neither want resources or seem to be deficient in experience.<sup>32</sup>

It is worth noting here that the Agra District at the time of its annexation was roughly twice its current size, comprising the trans-Jamna tracts of the later Mathura District as well as parts of the Mainpuri and Etah Districts. From all the available primary sources around 50% of the cultivated land use of the Doab from Delhi to Kanpur at the beginning of the 19th century can clearly be established. Of that between 80-90% was stable, well tilled agricultural land; 20%, as seen above, was forest; and, around 1808, 25% of the arable land usually lay fallow.<sup>33</sup> Thus almost 70% of the surface area can be accounted for and the agricultural situation described as satisfactory. In many areas an improvement could be expected, but under no circumstances does the picture of an insufficient and inefficient agrarian economy apply to the Doab.

### THE EXTENSION OF THE AGRARIAN AREA: 1806-1830

By 1805 the permanent state of war since 1756 had left the East India Company in dire financial straits. Already close to bankruptcy in 1770, the Company was brought once again to the edge of ruin by Governor Wellesley's wars. The Ceded and Conquered Provinces had to provide revenue, as much and as quickly as possible. As the officers in Calcutta and locally were of the opinion that little had changed since Akbar had set revenue levels, apart from an increase in agrarian production, they felt justified in raising demands by almost 20% in ten years. This could not have been achieved solely through an increase in food crops. In 1782 Pitt the Younger had indicated the future task of the East India Company in India in a confidential paper:

[...] the Export of the Manufacturers to India must not be checked, but encouraged to the utmost extent the demands of that country will admit and the like manner the utmost latitude must be afforded to the importation of much raw Materials for the Manufacturers of this Country, as the soil and climate of India are capable of producing.<sup>34</sup>

After the annexation of the Ceded and Conquered Provinces, the East India Company systematically turned the Doab into a cash crop area. As early as 1803 state investment was demanded for Doab farmers planting cotton.<sup>35</sup> Beside Etawah, centre of the cotton trade in north-west India, Lakhna, 16 miles south east of Etawah, and Pharaha, 50 miles inland to the north west, became established as local markets. Between 1810 and 1826 the number of trading

points grew further. Indigo, too, was extensively cultivated. In the Doab at the beginning of the 19th century this trade was almost exclusively in European hands. After the annexation of the Ceded and Conquered Districts local businessmen quickly became involved. The plantations had to be on a large scale, as only then were the domestic and overseas transport costs viable. The Home Authorities also pressed for a rapid expansion of cash crops.

The cultivation also may be carried too far, and occupation for a time considerable inconvenience, but that is an evil that may be expected in the end to work its own cure; and though, for these several causes, individuals may no doubt suffer, yet, speaking generally, the article seemed to be established as a great staple in Bengal. It supplies much of the consumption of Europe, and no rival to it seems likely to arise.<sup>37</sup>

From 1815 increased *taqavi* loans appeared to stimulate cash crop plantation. More specifically, cotton, indigo and sugar cane were subsidised in the individual districts. Banyas and Mahajans were thus able to control not only the state market, but also the production on the land.<sup>38</sup> The extension of the overall crop area was completed in the first 30 years of the 19th century. War and drought left the soil fallow for only around two years. Afterwards the land was again immediately put to the plough.<sup>39</sup> In 1815 the expansion of the cash crop area was in full swing. Between 1814 and 1840 it had doubled in the Aligarh area, and had already been growing since 1804.<sup>40</sup> In the Agra District the sugar cane crop alone grew by 5% between 1809 and 1816. By the middle of the 1830s the proportion of cotton fields in the Agra-Hodal region was between 20-40%.<sup>41</sup> In Etawah District the area of sugar cane crops grew by almost 20% between 1808 and 1814.<sup>42</sup> Here it should be noted that the Etawah District then covered one third of the Kanpur District as well as Etah and parts of Mainpuri. The Aligarh District owned almost half of the Bulandshahar District and the inter-fluvial parts of the Mathura District. In 1800 approximately 55% of the Doab between Delhi and Kanpur was cultivated, while in 1816 it was around 57%. By the 1830s it can be estimated that cultivated land formed something over 60% of the total. In real terms this is an increase of 20%. Simultaneously the proportion of cash crops grew from around 8% to almost 20%.<sup>43</sup>

The Indian peasants were forced into this expansion. Cash crops which were sold and exported through the East India Company at world market prices gained in price five times more than those of food crops, even on the Indian market.<sup>44</sup> This price differential, and a general fall in prices, a 25% currency depreciation<sup>45</sup> and a 20% increase in revenue demands drove the peasants to desperation.<sup>46</sup> Food production was marginalised and within a few years the best land was supporting cash crops, the peasants seeing this as a means of escaping from the vicious circle of debt and 'taxation'. At the same time crop areas were extended at the cost of the forest, which was cleared to provide new land.

## THE DEFORESTATION OF THE DOAB

In 1800 there was hardly any agriculture on the central lowlands. It was only around the larger towns like Manipuri, Etah, Etawah, Aligarh, etc., that the land was intensively farmed. The soil conditions in the inter-fluvial lowlands not only prevented an expansion of the cultivated area, but its dense forest guaranteed the climatic stability of the entire region. The central lowlands had heavy clay-loam soil and therefore provided only poor drainage, leaving only the Kali Nadi to perform this function effectively. The soil was therefore very salty and the only vegetation which could survive was the *dhak* tree.<sup>46</sup> Surface evaporation was reduced by shadow cover which, along with the trees' roots, increased its permeability. In this way the detrimental effects associated with salinisation did not occur. The *dhak* tree, then, occupied a remarkable ecological niche. Any interference with this natural equilibrium was bound to have lasting consequences.

Complementing the reports of agricultural expansion are others concerning the simultaneous onset of deforestation.<sup>47</sup> In Aligarh District before 1820, the northern part in particular and the then Bulandshahar District was covered with thick *dhak jangal*. Most of this *jangal* was cut down in the following three decades.<sup>48</sup> By 1840, with over half of the district cultivated further expansion could not be expected. The rest of the *dhak jangal* disappeared in the second half of the 19th century. By 1880 there were hardly any trees left outside the properties of the great Taluqdars.<sup>49</sup> In the mid 1820's there was still *dhak jangal* around Bharatpur.<sup>50</sup> According to a contemporary observer the belt of *jangal* up to three miles wide disappeared in the ten years following the British arrival there.<sup>51</sup> Around 1850 there was no remaining forest in the area beyond a small patch south of Bharatpur.<sup>52</sup> The forests in the Aligarh District extended into Mainpuri, Etah and Etawah. Here they were 30 km wide, right in the middle of the inter-fluvial-lowlands. By 1850 they had shrunk considerably, and by the end of the 19th century, apart from a few small patches of forest, every tree had been destroyed.<sup>53</sup> The *dhak jangal* in the Doab, which extended far beyond Kanpur, must for the main part have been chopped down in the first half of the 19th century, when Kanpur and Allahabad became cotton centres.<sup>54</sup>

No central planning concept lay behind the forest clearances, except probably for a British feeling that they offered the easiest way of extending the cultivable area. The Indian peasants, encouraged, and often compelled to gain new land, did this in a random, piecemeal fashion. Increasing demographic pressure and the foundation of many new village communities provided further impetus. Place names are modern reminders of the clearances, or rather of the earlier existence of the forest, mainly in the Aligarh and Mathura Districts: 'Dhakpura' and 'Khandia' are the most frequently found.<sup>55</sup> From hundreds of inhabited areas the peasants drove the forest ever further back. This was not, however, the only reason for the deforestation.

The British often established their authority over newly acquired land with the method of forest clearance that had already proved so effective in Scotland. After the destruction of the estates of Daya Ram of Hathras and Bhagwant Singh of Mursan areas of forest near Hathras were chopped down to protect British positions.<sup>56</sup> Similarly, large areas of *jangal* were destroyed, to deny robbers and other criminal elements, commonly known as ‘dacoits and bandits’, of their hiding places.<sup>57</sup> To prevent any threat to agrarian expansion *jangal* was cleared when it offered protection to tigers and other wild animals.<sup>58</sup> When there was no buyer for the estates of rebellious Zamindars which had been forcibly dissolved and auctioned, local British officers were ordered to chop down and sell the trees. The collector of Farrukhabad put this quite frankly:

I am induced to recommend this measure from a belief that the proprietors will come forward to make some arrangements for the payment of the balance without permitting a single tree to be touched, as the preparation even for the measure has proved effectual in many instances.<sup>59</sup>

This approach seems to have been usual and was also effective against late revenue payers.

In manufacturing bricks a no longer exactly calculable proportion of the felled timber was used for fuel.<sup>60</sup> The *pakka* construction of the stations and cantonments required vast amounts of bricks. Because the Ceded and Conquered Provinces were the furthest outpost of British rule until the middle of the 19th century, British properties were built on an appropriately grand scale. Here Kanpur, Agra, Delhi, Aligarh and Mirat are worth mentioning. An Indian observer at the time astutely remarked that whilst earlier foreign conquerers had left behind imposing architecture of artistic value, the British were only building barracks and prisons.<sup>61</sup> The British ban on new mango trees was particularly grotesque. W.H. Sleeman reported,

Our government has, in effect, during the thirty five years that it held the dominion of the North Western Provinces, prohibited the planting of mango-groves, while the old ones are everywhere disappearing. In the resumption of the rent-free lands, even the ground, on which the finest of these groves stand, has been recklessly resumed; and the proprietors told, that they may keep the trees they have, but cannot be allowed to renew them, as the lands are to become the property of government.<sup>62</sup>

Even before the rent free land was handed over to the state, the British did exactly what they liked with it. The British wanted to plant trees only as lasting boundary marks, otherwise they would lose the overview of their frontiers. Stones and charcoal obviously did not suffice as demarcation points.<sup>63</sup>

During the drought and famine of 1838 the British detailed peasants who came looking for help to public works projects, especially road building. Major projects in this period included the upgrading of the roads between Fategarh and Agra via Mainpuri and from Etawah to Mathura. This spared the British administration the cost of feeding imprisoned debtor peasants. In 1837-38 circa

250,000 people were drafted onto public utility projects in the North-Western Provinces.<sup>64</sup> But precisely this employment programme during the famine led to a further deforestation of the Doab. In the middle of the 19th century around 70% of the Doab's forest had been felled and the land was being used for agriculture. This unbridled exploitation of the land soon had climatic, agrarian and medical consequences.

### ECOLOGICAL CHANGE AND AGRARIAN DISTRESS

The first signs of climatic change were palpable after thirty years of British rule in the Doab. Here and in neighbouring Awadh temperatures rose and precipitation became irregular, decreasing in total. In 1849 'pankas' were introduced for the first time in British barracks, having been previously considered unnecessary. After 1850 they came into general use.<sup>65</sup> Contemporary observers like Donald Butter recognised that these climatic changes could be traced back to deforestation in the Doab, Awadh and in Bundelkhand.

The intensity of the winds grew. The *lu*, the hot wind which preceded the Monsoon, and the *andhi*, the sand and dust filled wind, both blow over the desert of Rajasthan to North India and deep into the Ganges valley. Donald Butter realised that the *lu* was caused by the soil's surface being heated. This effect was then exaggerated by the lack of forest to act as a natural barrier, rending it still hotter and more penetrating.<sup>66</sup> The general rise in temperature and the increased strength of the *lu* corresponded with the absence of rainfall.<sup>67</sup> A turning point in the ecology of the Doab was without doubt the great drought of 1837-38 which followed a succession of dry years beginning in the early 1830s. This drought was more than a natural swing of climatic mood; it was the cumulative effect of natural and man made causes, and this combination had catastrophic consequences. After more than two decades of continuous deforestation the ecological balance had been lost and natural regenerative processes no longer functioned.

The *lu* caused considerable erosion. Worse, it loosened the surface of the now unprotected soil, which was then washed away in the burst of the monsoon. Canal erosion took place in the headwaters of streams and rivers, finally drying up the springs.<sup>68</sup> In the 1840s after the prolonged dry period the sub-soil, of crucial importance for water storage, dried out substantially. The Collector of Mainpuri noted early in 1850,

That the soil of the Mynpoorie District does not contain the same depth of moisture which it did prior to the year 1837, and that this is proved by the fact that the Esun Nudee, which always contained a considerable body of running water throughout the hot season, before that year, has since become nearly dry, two months after the rainy season.<sup>69</sup>

The Isan Nadi flows exactly in the channel of the central lowlands north west of Etah until its junction with the Kali Nadi. At Mainpuri water tanks and *jhils*

also dried out, or the little water in them was brackish because of the dry ground and the lack of rain. This applied not only to the areas of the Jamna, but also in parts of Awadh and in Rohilkhand, where the forest was still largely untouched.<sup>70</sup> The remarkable thing about this statement is that the Collector was obviously aware of the nexus between the area of forest, expansion of farmed land and the reduction in rainfall.

Silting up of the *jhils* was seen as an insoluble problem. In the course of the monsoon they filled up with water, which then supplied a range of vegetation. During the dry season which followed most of the water evaporated and the plants died. Other *jhils* dried out completely. The rotting plant matter formed stinking malaria ridden mud. The surface area from which a *jhil* draws its water is roughly 5-10 times bigger than the *jhil* itself. Extension of its drainage area is impossible but not that of its inflow via the surface run-off. Thus left-over soil and the remains of the harvest were washed in to silt things up still further, and the whole was compounded by the increase in sand deposits from the pre-monsoonal wind (*andhi*)<sup>71</sup> The *dhak* forest in the central lowlands had not only functioned as a wind break, but had also slowed the transport of dust and sand with the *andhi* and the rising temperatures of the *lu*. The warming of the Doab from 1830 was, however, only one side of the climatic change. Because there were no more regulatory forces at work the incidence of frost increased, particularly in the case of November frosts.

[...] these frosts, which are more severe and frequent than formerly, are injurious to the country agriculturally; as various food-plants, particularly the arhar, are now more frequently killed by that frost that it was formerly the case.<sup>72</sup>

The extreme temperatures during the months preceding the monsoon caused an increase in heat related deaths.<sup>73</sup> At the start of the 19th century the wooded regions of the Doab and the southern districts of Awadh were still free of malaria.<sup>74</sup> This changed after deforestation as the water in tanks, *jhils*, and dried out river beds received more sunshine than before, turning them into breeding grounds for mosquitos where the larvae could develop.<sup>75</sup> The surgeons in the Bengal Army gave warnings about deforestation around the towns and villages, because they not only held back dust and sand, but also the spread of malaria and many other diseases. This was painfully obvious in Mathura and Muzaffarnagar, where malaria increased drastically in the course of the 19th century.<sup>76</sup> The first cholera epidemic in the Doab occurred during British rule in 1817. In the adjacent districts, too, cholera was only known from a few sporadic cases.<sup>77</sup> In 1821 a cholera epidemic of such proportions spread through the region that there was a shortage of wood to cremate the bodies.<sup>78</sup> After the droughts and famines of the mid 1820s and 1830s there were renewed epidemics. The cholera epidemics were, of course, not a result of the deforestation of large wooded areas in north India. But they do indicate a dramatic change in the ecological conditions of the Subcontinent at the beginning of the 19th century.

The climatic changes in the Doab had an immediate effect upon its soil fertility. On top of the various types of erosion, drying river sources and warming of the soil, there were the effects of ever more intensive farming. After deforestation the exposed soil in the central lowlands rapidly became saliferous. The forest had offered sufficient protection against this, but because of the increase in water evaporation the salt moved up to the surface and was deposited in the top soil, leading to a reduction in the soil's capacity to store water. Even today the volume of water left by the monsoon cannot be drained by the rivers and the central lowlands are regularly flooded.<sup>79</sup> Even in the 1820s the salinisation had gone so far that whole villages had to be abandoned because their fields were no longer productive. The first *usar* areas of any great size were in Mainpuri District and most of all in Etah District between Etah and Sidhpura. The Chambal-Jamna Doab became more arid too; *usar* areas appeared. Here the damage from wind and water erosion was most extensive. The area was so damaged that by 1880 the whole area was agriculturally worthless.<sup>80</sup> The condition of the soil in the Doab after the drought from 1833 to 1838 did not only raise the level of salinisation, it led to a weakening of the top soil. Europeans and Indians were of the unanimous opinion that the ground had been overstretched and that yields were lower in the 1840 than they had been in 1808.<sup>81</sup> This was the result of intensive farming which hardly left time for fallow periods and fertilisation. External factors such as deforestation and the warming of the region increased the likelihood of more intensive farming having negative consequences. Figures showing the drop in agricultural output are only available for the southern districts of Awadh. They reveal a 35% loss in the *rabi* harvest of wheat in 1836 in comparison with 1800. For *chana* this loss amounted to 23%. The *kharif* harvest produced 25% less unplanted rice whilst *kado* suffered a large 33% drop in yield. The barley crop remained relatively stable, falling by only 6%. On average agricultural production had dropped by 25%.<sup>82</sup> Only rough quantitative estimates are available for the Doab. A peasant from the Mathura District reported in 1835 that he had previously been able to produce more for his family from five acres that he now could from ten.<sup>83</sup> Such statements suggest a confirmation of the general trend of events in the Doab.

In the early 1850s the supply and availability of water had become so bad that the British government in India carried out a survey of the general condition of the land in the Agra Division, and the damage done to it. The individual reports show the extent of this damage with shocking clarity. C.P. Carmichael, Officiating Secretary to the Sudder Bord of Revenue, N.W.P., had to record in 1854, that:

To whatever cause the fact is to be attributed, whether to the general rise, bodily, of the land over an extensive tract, to a diminution of the annual quantity of rain arising from a decrease of trees or other influence, or to be the actual lessening and subsistence of the body of water percolating at a depth through the soil, it is now generally admitted that, extensively in the Agra, and partially also in other divisions,

great numbers of substantial wells have become dry, and new ones have to be dug deeper than before, *nadees*, which used to run constantly, have a stream only in the rains, and the surface of the soil has less moisture than in former periods.<sup>84</sup>

The long dry period in the Doab from 1833 to 1837, followed by the drought of 1837-8 led to a collapse of the ecological conditions. In 1838 one third less water flowed through the Ganga and Jamna than was usual in the dry period.<sup>85</sup> The water table fell seriously after 1838. In the south west of the Agra District its level fell from 47' in 1837 to 58'. At the end of the 18th century the water table in what was later the Mainpuri District was at around 10'-12'. By 1875, when more precise figures were taken it had fallen to 30'-100' in the south, 10'-30' in the centre and in the north was at 12'-25'. Thus here too, a sometimes dramatic fall in the water table should be noted. The results of the survey in the individual districts charted a drop in working wells of 11,121 between 1840 and 1853 in the Agra Divisions, which means a total fall of 18% of the *pakka* wells.<sup>87</sup> This loss was shared by all the Districts of the Agra Division, but was especially bad in Mainpuri, which suffered a drop of over 20%. This gives further evidence of the direct consequences of deforestation, since this district lay for the main part in the inter-fluvial central lowlands. As seen above, the road from Farrukhabad to Aligarh was noted for its plentiful supply of working wells. Now this water supply could only be maintained with the help of massive *taqavi* loans, which were originally meant to support the excavation of new wells.<sup>88</sup> *Taqavi* loans were granted for three years according to revenue and rent. Even locally based British officers criticised this form of credit for its short repayment period.<sup>89</sup> The British often tied these loans to an obligation to provide more security by cultivating cash crops. The East India Company treasury took advantage of the Indian peasants' hopeless and desperate situation, whilst still furthering the environmental destruction it had caused. Before long, both peasants and rulers would pay a high price for this short-sighted policy. But that is another story.

## NOTES

<sup>1</sup> c.f. E. P. Odum, *Fundamentals of Ecology* (New York 3rd ed. 1973). Ecology can further be subdivided into aut-ecology, describing the interaction of organisms within their inanimate environment, and syn-ecology, describing the interaction of living communities within a common living space. Here we shall deal with the latter.

<sup>2</sup> One cannot of course exclude the possibility of a series of catastrophes over a short period causing permanent damage to, or even destroying a region's ecology. The formation of the Friesian Islands off the German North Sea coast after a flash flood is such a case. Yet this should be seen as a rare exception rather than a recurring natural event.

<sup>3</sup> Crosby, Alfred W., *Ecological Imperialism. The biological expansion of Europe, 900-1900*. (Cambridge 1986). Crosby argues from the American perspective. It should not be forgotten that the plague which broke out in Europe in the mid 14th century had moved

slowly from the South Asian region and that Europeans had no immunity against this illness. Within a hundred years the population of Europe was halved. Continued European susceptibility to 'tropical diseases' was demonstrated in the 1890s when an outbreak of cholera in Hamburg led to 80,000 deaths. Finally one should also note that whilst millions of Europeans emigrated to the Americas, hardly any Americans came to Europe. The interaction between Asians and Europeans remained at the level of the bare minimum.

<sup>4</sup> Biermann, K. *Miscellanea Humboldtiana. Beitrage zur Alexander von Humboldt Forschung* (Berlin 1990), pp. 73-84.

<sup>5</sup> In Germany the Goettingen School around Friedrich Blumenbach had developed into the international avant-garde of natural science producing Georg Forster and Alexander von Humboldt. These scholars found British interest in their ideas at the Scottish universities, where many surgeons were educated who went on to serve in the Bengal Army, c.f. Grove, R. *Conservation and colonial expansion. A study of environmental attitudes and conservation policies on St. Helena, Mauritius, and in India. 1660-1860* (Cambridge, Ph.D. thesis 1988), ch 4, pp. 199-206.

<sup>6</sup> Cox, G. W. and M. D. Atkins, *Agricultural Ecology. An analysis of world food production systems* (San Francisco 1979), p. 147.

<sup>7</sup> Ahlheim, K.-H. (ed), *Die Umwelt des Menschen*, (Mannheim 1981), p. 288.

<sup>8</sup> Prinz, D., 'Erhaltung und Verbesserung der landwirtschaftlichen Produktivitaet in den Tropen und Subtropen', in: Rehm, S., *Grundlagen des Pflanzenbaus in den Tropen und Subtropen. Handbuch der Landwirtschaft und Ernaehrung in den Entwicklungslaendern* (Stuttgart 1986), Band 3, p. 127.

<sup>9</sup> Kalpage, F.S.C.P., *Tropical Soils. Classification, fertility, and management* (Delhi etc. 1974), p. 82.

<sup>10</sup> *ibid.*, p.62-63.

<sup>11</sup> *ibid.*, p.84-86, Table 28 (p. 86) Influence of soil colour on solar radiation absorbed. Grey alluvial soil, 40%; grass covered soil, 60%; charcoal powder, 94%; black cotton soil, 86%.

<sup>12</sup> Cannell, G.H. and L.V. Weeks, 'Erosion and its control in semi-arid regions', in: Hall, A.E. et al., *Agriculture in semi arid environments* (Berlin, Heidelberg, New York 1979), p. 240.

<sup>13</sup> Cox, G.W. and M.D. Atkins, op. cit. , p. 249.

<sup>14</sup> *ibid.*, p. 293.

<sup>15</sup> *ibid.*, p. 141.

<sup>16</sup> *khadar* = alluvial soil, swamp; *bangar* = pasture.

<sup>17</sup> *ban* = forest; *katna* = to cut.

<sup>18</sup> Nitz, H.-J., *Formen der Landwirtschaft und ihre raeumliche Ordnung in der oberen Gangesebene*. (Wiesbaden 1971), p. 10-21.

<sup>19</sup> c.f. Mann, M., *Britische Herrschaft auf indischem Boden. Landwirtschaftliche Transformation und oekologische Destruktion des 'Central Doab' 1801-1854* (Stuttgart 1992) p. 107-114.

<sup>20</sup> Dwivedi G.Ch., *The Jats* (G.Ch. Bangalore etc. 1989), p. 224-226

<sup>21</sup> c.f. *District Gazetteers of the United Provinces of Agra and Oudh*, (DGUP), vol. VII, Mathura, p. 1 and *Imperial Gazetteers*, vol. III, Etawah District (London 1881), p. 22.

<sup>22</sup> Lieutenant Rind's Routes in the Doab 1787 (in three parts), Map Room IOL; DGUP vol. X, Mainpuri (Allahabad 1911), p. 23; Final Report on the Revision of Settlement in the District of Aligarh, p. 3, para. 10; Home Misc. Series 776, Appendix to Lord Moira's

Minute 2nd Oct. 1815 on the Judicial Administration of the Presidency of Ft. William, vol. 2, No. 27, 13th Jan. 1818, reced. 2 July 1818 para. 9.

<sup>23</sup> Lieutenant-Colonel Pester, Bengal Army 1801-26, Military Campaigns 1801-1806, Mss Eur D, 434, p. 11-16.

<sup>24</sup> Mr Girdlestone, Famine Report 1803, in: *Report on the Settlement of the Etawah District* (Allahabad 1875), p. 33; Acting Agent to the Governor General, Furruckabad 23rd May 1805, Ft. William 9th April 1805. Bengal Revenue Proceedings, Ceded Provinces, 1805 IOL (90/47) and DGUP, vol. X, Mainpuri (Allahabad 1911), p. 60.

<sup>25</sup> Banerji, B. *Begum Samru* (Delhi 1989), p. 139 and 164.

<sup>26</sup> Journal in India from August 15th, 1803, to September 25th Delhi. Mss Eur. D.117; Lieutenant-Colonel J. Pester, Bengal Army 1801-1806, Mss Eur. D.434, pp. 11-13, 62-63, 83-115.

<sup>27</sup> Journal in India, Mss Eur. D 117.

<sup>28</sup> *ibid.*

<sup>29</sup> From Messrs. R.W. Cox and H.St. Tucker, to all Collectors (Circular), in: *Selections from Revenue Records, N.W.P.* (Allahabad 1873), vol. III, No. I, pp. 279-284

<sup>30</sup> From the Acting Clltr. of Furruckabad, to the Board of Commissioners, 28th Dec. 1807, in: *ibid* No. II, p. 311.

<sup>31</sup> From the Acting Clltr. of Etawah, to the Board of Commissioners, 28th Oct. 1807, in: *ibid*, pp. 315-317.

<sup>32</sup> From the Acting Clltr. of Agra, 29th Sept. 1807, *ibid*, p. 334.

<sup>33</sup> Extension of the Permanent Settlement to the CCP. Notes by Mr Cumming on Bengal minutes of 1814 and 1820, Home Misc. Series 530, vol. 5 of Mr Cumming's Papers, pp. 12-13, and *Parliamentary Papers*, vol. 10 (1812-13), Copy of minute recorded by Mr Colebrook, on the revenue consultations of Bengal, 20th Juni 1808; respecting the extension of the permanent settlement to the CCP, para. 6, p. 253.

<sup>34</sup> Memorandum respecting the future Government of India, for Mr Russel's Instructions, Pitt Papers: East India Company, Engl. Mss 292 (JRULM, Manchester).

<sup>36</sup> Report on the Commerce and Customs of the Ceded Provinces (enclosure), Patna 20th Oct. 1803, para. 44.

<sup>37</sup> *ibid.*, para. 48 and H. Newman, Clltr of Gvt Customs to Board, 1 Nov. 1826, reprod. NWP Revenue Customs, Jan 1836 IOL (221/85). c.f. Bayly, *Rulers, townsmen and bazaars* (Cambridge 1983), p. 264.

<sup>38</sup> *Reports and Documents, III, Report of the Proceedings of the EIC in regard to the Culture and manufacture of Indigo, Papers relating to the Culture and Manufacture of Indigo* (London 1836), No. 20, Extract letter from the Court of Directors to the Governor General, Bengal, 20th June, 1810, p. 72-73, para. 74.

<sup>38</sup> C. Bayly, *op. cit.*, p. 215.

<sup>39</sup> A. Ross, Clltr. of Agra, to Board of Revenue, Agra 25th July 1806, Ft. William 12th August 1806, Bengal Revenue Proceedings (BRP) 1806 IOL (90/53).

<sup>40</sup> *Final Report on the Revision of Settlement in the District of Aligarh* (Allahabad 1882), p. 62-3.

<sup>41</sup> Bayly, *op. cit.*

<sup>42</sup> H. Dawes, Clltr. of Etawah, to the Board of Commissioners, Zillah Etawah 15th April 1816, Furruckabad 19th April 1816, No. 8 (Enclosure: Statement showing the comparative Extension which has taken place in the cultivation of Sugar cane in the District of Etawah since the year 1808, A.D., (BRP), CCP 1816, IOL (92/56).

- <sup>43</sup> The basis of these figures has been elaborated in detail in: M. Mann, *Britische Herrschaft auf indischem Boden*, p. 145-46.
- <sup>44</sup> A. Siddiqi, Agrarian depression in Uttar Pradesh, *Indian Economic and Social History Review* 6, 2 (1969), p. 175, 177.
- <sup>45</sup> A. Siddiqi, *Agrarian change in a northern Indian state. Uttar Pradesh 1819-1833* (Oxford 1973), p. 173 and c.f. K. N. Chaudhuri, Indian international economy in the nineteenth century, *Modern Asian Studies* 2 (1967), p. 41
- <sup>46</sup> *ibid.*, p. 17; D. Brandis, *The Forest Flora of North-West and Central India* (London 1874), p. 142.
- <sup>47</sup> Home Misc. Series 776, Appendix to Lord Moira's minute 2nd Oct. 1815, Judicial Furruckabad, No. 22 in No. 2, part 3, para. 5.
- <sup>48</sup> *ibid.*, No. 27 in No. 2, para. 9.
- <sup>49</sup> DGUP, vol. VI, Aligarh (Allahabad 1909), pp. 19, 33; J. R. Hutchinson, *Alligurh Statistics* (Roorkee 1856), p. 23 and *Final Report of the Settlement of the District of Aligarh*, p. 3, para. 10.
- <sup>50</sup> E.W. Raleigh, The Log of a Griffin, Mss Eur. D. 786-2, p. 47-8.
- <sup>51</sup> H. W. Sleeman, *Rambles and Recollections* (London 1844), vol. I, p. 75.
- <sup>52</sup> *From Sepoy to Subedar; being the life and adventures of Subedar Sita Ram* (ed. by James Lunt, London 1970), p. 24.
- <sup>53</sup> DGUP, vol. X, Mainpuri (Allahabad 1911), p. 23 and *Report on the Settlement of the Mainpuri District* (1875), p. 10.
- <sup>54</sup> DGUP, vol. XIX Cawnpore (Allahabad 1909), p. 3 and pp. 13-14.
- <sup>55</sup> J. M. Siddiqi, *Aligarh District: a historical survey* (New Delhi 1981), p. 10, 15.
- <sup>56</sup> N. Newnham, Secretay to the Board of Commissioners, to the Clltr. of Allygurh (C.F. Fergusson), Furruckabad 29th Dec. 1818. BRP, IOL (93/39).
- <sup>57</sup> *Report on the Settlement of the Mainpuri District* (Allahabad 1875), p. 10.
- <sup>58</sup> Home Misc. Series 776, Appendix to Lord Moira's Minute, Judicial Furruckabad, No. 22, in No. 2, part 3, para. 5.
- <sup>59</sup> J. Donithorm, Clltr. of Furruckabad, to Board of Commissioners, Furruckabad, to Board of Commissioners, Furruckabad 16th Oct. 1818, Furruckabad 23rd Oct. 1818, BRP, CCD 1818. IOL (93/37), No. 14, para. 4.
- <sup>60</sup> A. F. Corbett, *The climate and resources of Upper India* (London 1874), pp. 65-6.
- <sup>61</sup> C.A. Bayly, *The Imperial Meridian* (Harlow 1989).
- <sup>62</sup> W.H. Sleeman, *op. cit.*, vol. I, p. 177.
- <sup>63</sup> R.N.C. Hamilton, Offg.-Cmmr. of the Agra Division, to the Sudder Board of Revenue, Agra 3rd May 1838, and copy of a letter from J.H. Robinson, Clltr. of Furruckabad, to R.N.C. Hamilton, Furruckabad 24th April 1838. N.W.P., Sudder Board of Revenue Proceedings, IOL (222/27), No. 89.
- <sup>64</sup> Report of the Agra Relief Society, No. 192, Proceedings of March, 10th March 1838. N.W.P., Judicial Proceedings, Criminal 1838 IOL (231/47).
- <sup>65</sup> D. Butter, *Southern Districts of Oud'h* (Calcutta 1839), p. 16 and A. Corbett, *op. cit.*, pp. 6-7.
- <sup>66</sup> D. Butter, *op. cit.*, p. 23; A.F. Corbett, *op. cit.*, pp. 4-5.
- <sup>67</sup> *ibid.*
- <sup>68</sup> *ibid.*, pp. 22-23.
- <sup>69</sup> *Selections from the Records of Government, N.W.P.*, (Allahabad 1873), vol. III, part XII to XXI, art XXIII, 'Note on the decrease in the number of wells since the settlement under

the Regulation IX of 1833, in the districts of Muttra, Agra, Mynpoorie and Etawah, in the Agra Division', p. 341 (7).

<sup>70</sup> *ibid.*, p. 354; From the Hon'ble R. Drummond, Offg. Clltr. of Agra, to H. Unwin, Cmmr. of Revenue, No. 321, Agra, Agra 12th Sept. 1854.

<sup>71</sup> A.F. Corbett, *op. cit.*, pp. 39-41.

<sup>72</sup> *ibid.*, p. 2; D. Butter, *op. cit.*, p. 17.

<sup>73</sup> Corbett, *op. cit.*, p. 10.

<sup>74</sup> Butter, *op. cit.*, p. 6.

<sup>75</sup> Corbett was aware of this, *op. cit.*, p. 40.

<sup>76</sup> I. Klein, Population growth and mortality, pt. II, *Indian Economic and Social History Review* 27, 1 (1990), p. 49.

<sup>77</sup> Butter, p. 168, The local population believed the appearance of epidemics was connected with their service in the British-Indian army and the increased mobility of EIC employees caused by the expansion in trade. *c.f. ibid.*, p. 173. These observations were absolutely right as studies of the late 19th century and the inter-war period of this century show. Continuing modernisation sped up the spread of diseases, 'modernisation helped disrupt the old 'local' ecological balances and disseminated disease vectors and microbes rapidly around the country.' I. Klein, *op. cit.*, pt. I, *Indian Economic and Social History Review*, 26, 4 (1989), p. 403.

<sup>78</sup> DGUP, vol. VI, Aligarh (Allahabad 1909), p. 29.

<sup>79</sup> H.J. Nitz, *op. cit.*, p. 20 and DGUP, vol. XIX, Cawnpore (Allahabad 1909), p. 4.

<sup>80</sup> *Imperial Gazetteer*, (London 1881), vol. III, Etawah District, p. 226.

<sup>81</sup> *Report on the Settlement of the District of Agra* (Agra 1842), p. 6.

<sup>82</sup> Butter, *op. cit.* p. 57, 'Kharif Crops, sown in Rainy Season' and p. 58, 'Rabi Crops, sown in the Cold Season'.

<sup>83</sup> W.H. Sleeman, *op. cit.*, pp. 147-148.

<sup>84</sup> *Selections from the Records of Govt, N.W.P.*, (Allahabad 1873) vol. III, 'Note on the decrease in the number of wells'; from C.P. Carmichael, Offg. Secretary to the Sudder Board of Revenue, N.W.P., No. 108, Agra 21st Feb. 1854, pp. 351-2.

<sup>85</sup> *Parliamentary Papers*, vol. 40 (1862), Accounts and Papers; Copies of the Report of Colonel Baird Smith to the Indian Government. 'Further Report on the Famine 1860-61 in the N.W.P. of India, p. 85.

<sup>86</sup> *ibid.*, p. 342(5).

<sup>87</sup> *ibid.*, Abstract submitted by the Sudder Board of Revenue to Government on the 12th August 1850.

<sup>88</sup> R.N.C. Hamilton, Offg. Cmmr. of the 2nd Division to SBR, Agra 18th Feb. 1839, Sudder Board of Revenue, N.W.P. 8th March 1839, N.W.P., SBR Proceeding 1839, IOL (222/49).

<sup>89</sup> *Selections from the Records of Government, N.W.P.*, (Allahabad 1873), vol. III, 'Note on the decrease in the number of wells'; Report from Mr M.R. Gubbins, Clltr. of Agra, No. 270, 17th Sept. 1853, p. 349.